THE BRITISH SOCIETY FOR THE PROMOTION OF VEGETABLE RESEARCH

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Tenth Annual Report

1959

(OCT. 1958 - SEPT. 1959)

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NATIONAL VEGETABLE RESEARCH STATION

WELLESBOURNE - - WARWICK

Telephone : Wellesbourne 382 (3 lines)

1960

CONTENTS

		Page
The Constitution of the National Vegetable Research Station		iv
LIST OF:		
GOVERNING MEMBERS OF THE SOCIETY		v
MEMBERS OF THE EXECUTIVE COMMITTEE and the SUB-COMMITTEES		vi
STAFF		vii
REPORT OF THE DIRECTOR:		
Opening of the new laboratory building by H.R.H. The Duke of Edinburgh		1
Other development		2
Staff		2
Research		5
N.V.R.S. Association		10
FARM	*T. J. Norwood*	14

Research Reports

PLANT BREEDING	*J. C. Haigh*	15
CHEMISTRY	*F. Haworth*	20
PLANT PHYSIOLOGY	*E. J. Winter*	26
IRRIGATION	*E. J. Winter*	30
ENTOMOLOGY	*D. W. Wright*	35
PLANT PATHOLOGY	*W. G. Keyworth*	40
WEED INVESTIGATIONS	*H. A. Roberts*	44
The effects of different methods of seed-bed preparation on weed emergence	*J. K. A. Bleasdale and H. A. Roberts*	46
STATISTICS	*J. A. Nelder*	50
THE WEATHER DURING 1959	*Christine Down, E. J. Winter and R. B. Austin*	52
LIBRARY	*Barbara M. Moore and H. A. Roberts*	56
PUBLICATION RECORD		57
MAPS		
Wellesbourne		61
Paglesham		62
Route Map		63

THE CONSTITUTION OF
THE NATIONAL VEGETABLE RESEARCH STATION

The National Vegetable Research Station (N.V.R.S.) at Wellesbourne, Warwickshire, and its Sub-Station at Paglesham, Essex, were established under a Governing Body incorporated on 28th September 1949 as a company limited by guarantee, not having a share capital, and having the title 'The British Society for the Promotion of Vegetable Research', with its registered office at Wellesbourne.

The members of the Governing Body, twenty-three in number, include nominees of the Lord President of the Council and of the two Agricultural Departments of Great Britain, of the Department of Scientific and Industrial Research, of various learned societies, universities and institutions concerned with horticulture, of vegetable producers (through the National Farmers' Unions of the two countries and the National Allotments and Gardens Society) and of trade interests.

The properties at Wellesbourne and Paglesham are leased to the Society by the Agricultural Research Council (A.R.C.) and by the Ministry of Agriculture, Fisheries and Food, respectively. Until 31st March 1956, the Society depended for its funds on grants from this Ministry who were advised by the A.R.C. regarding research work and staff. On 1st April 1956, the grant-aiding functions of the Ministry were transferred to the A.R.C. If the Society establishes stations or conducts work in Scotland, grants will be receivable from the Scottish Agricultural Advisory Council who will be advised by the A.R.C.

GOVERNING MEMBERS OF THE SOCIETY

Appointed by the Lord President of the Council, the Minister of Agriculture, Fisheries and Food, and the Secretary of State for Scotland:

Professor K. MATHER, C.B.E., D.Sc., F.R.S., Department of Genetics, The University, Edgbaston, Birmingham, 15.

W. J. F. SOPER, Esq., J.P., New Hall Farm, Harlow, Essex.

Professor P. T. THOMAS, B.Sc., Ph.D., Department of Agricultural Botany, The Institute of Rural Science, University College of Wales, Penglais, Aberystwyth.

Principal M. A. H. TINCKER, M.A., D.Sc., F.R.S.E., F.L.S., The North of Scotland College of Agriculture, 41½ Union Street, Aberdeen.

Professor C. W. WARDLAW, Ph.D., D.Sc., D.Sc. (Hon. McGill University), F.R.S.E., F.L.S., Department of Botany, The University, Manchester, 13.

Appointed by the Department of Scientific and Industrial Research:

R. G. TOMKINS, Esq., M.A., Ph.D., Ditton Laboratory, Larkfield, Maidstone, Kent.

Appointed by the University of London:

Professor H. W. MILES, Ph.D., D.Sc., Wye College (University of London), Ashford, Kent.

Appointed by the University of Reading:

Professor O. V. S. HEATH, D.Sc., F.R.S., Department of Horticulture, The University, Reading, Berks.

Appointed by the University of Cambridge:

J. BARKER, Esq., M.A., Ph.D., F.R.S., The Botany School, Downing Street, Cambridge.

Appointed by the University of Bristol:

Professor H. G. H. KEARNS, O.B.E., B.Sc., Ph.D., Dip. Agric., University of Bristol, Department of Agriculture and Horticulture, Research Station, Long Ashton, Bristol.

Appointed by the University of Edinburgh:

ALEXANDER NELSON, Esq., Ph.D., D.Sc., F.R.S.E., University Department of Botany, at Royal Botanic Garden, Edinburgh, 3.

Appointed by the Royal Society:

Professor W. BROWN, M.A., D.Sc., F.R.S., The Bush, Haddenham, Aylesbury, Bucks.

Appointed by the John Innes Horticultural Institution:

K. S. DODDS, Esq., Ph.D., D.Sc., Bayfordbury, Herts.

Appointed by the National Farmers' Union:

F. M. BARDSLEY, Esq., Low Mill Farm, East Ayton, Scarborough, Yorks.

R. FORD, Esq., Began Farm, St. Mellons, Cardiff, Glamorgan.

G. G. HOLE, Esq., Pakyns, Hurstpierpoint, Sussex.

J. LAITY, Esq., Polkinghorne, Gwinear, Hayle, Cornwall.

W. F. SWIFT, Esq., Avon Cottage, Fladbury, Pershore, Worcs.

Appointed by the National Farmers' Union of Scotland:

DAVID LOWE, Esq., C.B.E., Elvingston, Gladsmuir, East Lothian. (Chairman).

Appointed by the Horticultural Trades' Association:

J. S. W. CRACKNELL, Esq., O.B.E., V.M.H., 120 Waldegrave Road, Teddington, Middlesex.

Appointed by the Royal Horticultural Society:

Professor T. WALLACE, C.B.E., M.C., D.Sc., F.R.I.C., V.M.H., F.R.S., 'Redwings', Old Church Road, Nailsea, Somerset.

Appointed by the National Allotments and Gardens Society:

Professor J. CALDWELL, Ph.D., D.Sc., Hatherly Biological Laboratories, Prince of Wales Road, Exeter.

Appointed by the Seed Trade Association of the United Kingdom:

F. HOLL, Esq., Harrison and Sons (Leicester) Ltd., St. James' Street, Leicester.

The Executive Committee

Professor W. BROWN
J. S. W. CRACKNELL, Esq.
Professor O. V. S. HEATH
G. G. HOLE, Esq.
J. LAITY, Esq.
DAVID LOWE, Esq.
Professor K. MATHER
W. F. SWIFT, Esq.
Professor T. WALLACE (Chairman)
Professor C. W. WARDLAW

Staff and Research Sub-Committee

Professor W. BROWN (Chairman)
J. S. W. CRACKNELL, Esq.
R. FORD, Esq.
Professor O. V. S. HEATH
Professor H. G. H. KEARNS
DAVID LOWE, Esq.
Professor K. MATHER
W. J. F. SOPER, Esq.
Dr. R. G. TOMKINS
Professor T. WALLACE
Co-opted:
C. E. HUDSON, Esq., C.B.E., N.D.H., V.M.H., Ministry of Agriculture, Fisheries and Food, Great Westminster House, Horseferry Road, London, S.W.1.

Farm Management Sub-Committee

F. M. BARDSLEY, Esq.
G. G. HOLE, Esq.
F. HOLL, Esq.
J. LAITY, Esq.
W. J. F. SOPER, Esq.
W. F. SWIFT, Esq. (Chairman)
Co-opted:
F. H. VANSTONE, Esq., B.Sc., Ph.D., A.Inst.P., Head of Horticultural Engineering Department, National Institute of Agricultural Engineering, Wrest Park, Silsoe, Beds.

Varieties Inspection Sub-Committee

J. S. W. CRACKNELL, Esq.
DAVID LOWE, Esq. (Chairman)
G. G. HOLE, Esq.
F. HOLL, Esq.
W. F. SWIFT, Esq.
Co-opted:
C. D. R. DAWSON, Esq., Ph.D., Pyports, Cobham, Surrey.
F. G. POTTER, Esq., Sutton and Sons Ltd., The Royal Seed Establishment, Reading, Berks.
L. A. W. PRIOR, Esq., W. Deal and Sons Ltd., Kelvedon, Essex. (From 29/6/59)

STAFF

Director:
JAMES PHILP, B.Sc. (Glas.), Ph.D. (Lond.).*

Deputy Director:
D. W. WRIGHT, M.A. (Cantab.).*

Plant Breeding: J. C. HAIGH, B.Sc., Ph.D. (Lond.), A.R.C.S., A.I.C.T.A.
H. HOLLAND, B.Sc. (Wales).
A. G. JOHNSON, B.Sc. (Lond.), Ph.D. (Wales).
L. E. WATTS, B.Sc. (Wales).
G. J. FAULKNER.
G. J. FROST, B.Sc. (Dunelm).
R. A. T. GEORGE.
Miss E. M. SLADE, B.Sc. (Bristol).
Assistants: Miss D. E. ALLEN.
Mrs. J. M. H. AUSTIN (née INSLEY).
Miss C. H. BEARDALL, Dip. Hort. (Nott.). (Resigned 20/8/1959)
Miss S. R. C. CHURCHILL. (Appointed 1/9/1959)
Miss P. A. DYMOND.
Miss W. HILES. (From 1/11/1958 to 22/9/1959)
I. MITCHELL.
B. WOODWARD.

Chemistry: F. HAWORTH, B.Sc., Ph.D. (Liverpool), Dip. Ag. Sci. (Cantab.).
S. P. SPRAGG, B.Sc., Ph.D. (Bristol).
D. J. GREENWOOD, B.Sc. (Liverpool), Ph.D. (Aberdeen). (Appointed 1/1/1959)
T. J. CLEAVER.
Miss P. M. LIEVESLEY, B.Sc. (Bristol).
Assistants: Miss M. A. BENNETT.
Miss P. CHANDLER.
M. J. CLAYTON.
D. GOODMAN. (Appointed 27/4/1959)
Miss E. A. PLATT. (Resigned 18/3/1959)

Physiology: E. J. WINTER, M.C., M.Sc. (Bristol).
J. K. A. BLEASDALE, B.Sc., Ph.D. (Manc.).
R. B. AUSTIN, B.Sc. (Birm.).
R. THOMPSON, B.Sc. (Lond.). (Appointed 1/4/1959)
Assistants: Mrs. I. H. FROST.
B. G. HUNT. (Appointed 21/9/1959)
Mrs. J. I. E. MITCHELL (née RUBIO).
Miss C. J. SNELL. (Resigned 12/9/1959)
Miss S. SMITH.

Irrigation: E. J. WINTER, M.C., M.Sc. (Bristol).
P. J. SALTER, M.Sc. Hort., Ph.D. (Nott.).
D. H. DREW, B.Sc. (Lond.).
P. J. M. SALE, B.Sc. Hort., Ph.D. (Reading). (Appointed 11/8/1959)
Miss F. L. C. BLACKWALL, B.Sc. Hort. (Lond.), Dip. Hort. (Studley).
J. B. WILLIAMS, B.Sc. (Sheffield). (Appointed 1/1/1959)
Assistants: Miss J. BANNAN.
Miss A. CARPENTER. (From 10/11/1958 to 31/7/1959)
Miss C. DOWN.
Miss S. HEMMINGS.
G. M. R. TRUEMAN.
Miss K. VINCENT. (Appointed 4/9/1959)

*Recognised lecturer of the University of Birmingham.

Entomology: D. W. WRIGHT, M.A. (Cantab.).*
T. H. COAKER, B.Sc. (Lond.), D.I.C. (Appointed 21/7/1959)
J. A. DUNN, M.Sc. (Dunelm), Ph.D. (Birm.).
G. A. WHEATLEY, B.Sc. (Dunelm).
R. D. HUGHES, B.Sc., Ph.D. (Lond.). (Resigned 31/7/1959)
J. A. HARDMAN, B.Sc. Hort. (Nott.).
Mrs. D. D. SALTER, B.Sc. (Dunelm).
Miss J. WORRALL, B.Sc. (Lond.).
Assistants: H. I. SMITH.
Miss G. D. BUBB.
Miss C. LOWE.
K. NIENDORF. (Appointed 1/3/1959)
Mrs. J. SELWYN (née MARCH).
Mrs. C. R. SLAUGHTER. (Resigned 15/10/1958)
Miss J. TILSLEY. (Appointed 16/10/1958)

Pathology: W. G. KEYWORTH, B.Sc., Ph.D. (Lond.), A.R.C.S., D.I.C.*
A. G. CHANNON, B.Sc. (Aberdeen).
R. B. MAUDE, B.A. (Dublin), M.Sc. (Nott.).
J. A. TOMLINSON, B.Sc., Ph.D. (Birm.).
Miss R. P. GOODCHILD, B.Sc. (Leeds).
Miss J. S. HOWELL, B.Sc. (Birm.).
Miss B. R. SMITH, B.Sc. Hort. (Lond.).
M. J. W. WEBB, B.Sc. Hort. (Nott.).
Assistants: Mrs. G. A. DAYES. (Appointed 5/1/1959)
Miss J. M. DOW.
Miss M. P. INSALL.
Mrs. P. A. KNIBB. (Resigned 30/11/1958)
Miss J. TAYLOR.

Weeds: H. A. ROBERTS, B.Sc. (Manc.).
J. M. WAY, B.Sc. Hort., M.Sc. (Lond.). (Working under A.R.C. grant)
Miss S. M. S. HIRD, B.Sc. (Lond.), M.Sc. (Saskatchewan).
Miss M. E. SMART, B.Sc. (Lond.). (Resigned 30/11/1958)
Bernard J. WILSON, B.Sc. Agric. (Reading). (Appointed 2/2/1959)
Assistants: Mrs. A. H. T. GEORGE.
Miss U. W. LAURENCE.
Miss C. A. LEADBEATER, Dip. Hort. (Studley).
(Appointed 24/8/1959 under A.R.C. grant)
Brian J. WILSON.

Statistics: J. A. NELDER, M.A. (Cantab.).*
Miss L. A. KEMP, B.Sc. (Lond.). (Appointed 1/9/1959)
Miss K. M. WILSON, B.Sc. (Reading). (Appointed 1/12/1958)
Assistants: Miss A. DRAYCOTT.
Miss H. E. RUSSELL.
Miss A. R. TUFFIN.

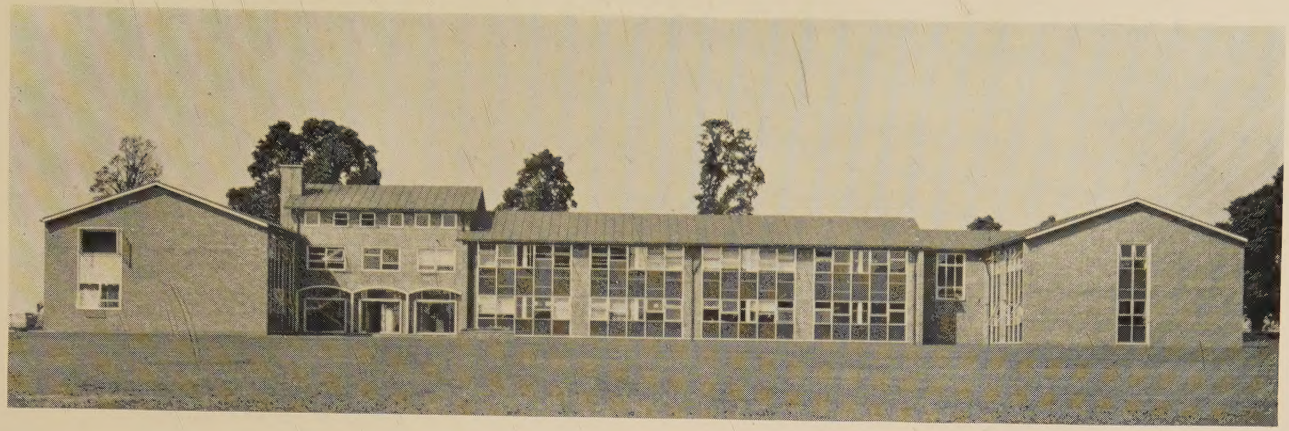
Librarian: Miss B. M. MOORE, N.D.D.H. (Resigned 31/5/1959)

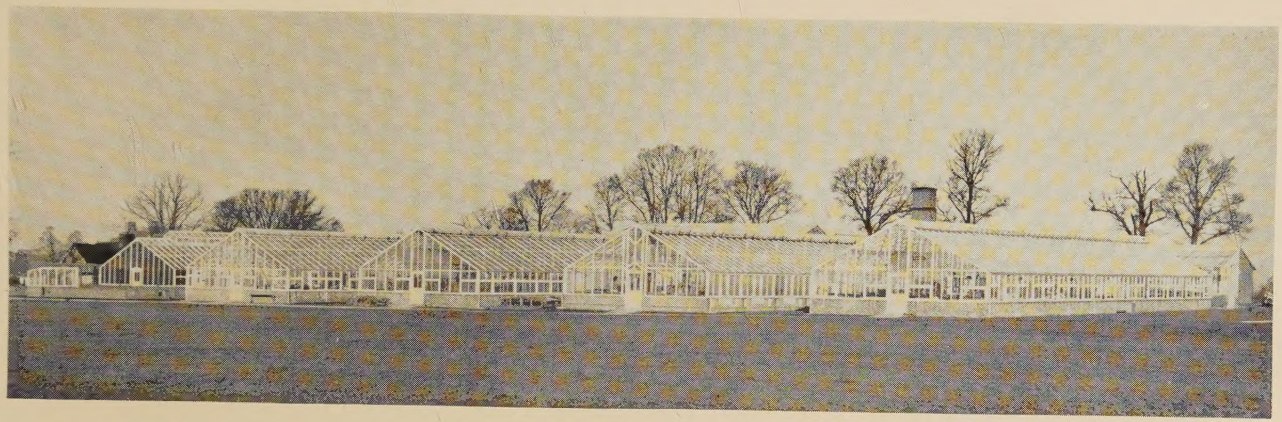
Photographer: R. H. MOCKFORD. (Appointed 3/11/1958)

Farm: *Manager:* T. J. NORWOOD.
Wellesbourne—Senior Farm Assistant: W. G. BROWN, N.D.A., N.D.D. (Appointed 6/10/1958)
Senior Glasshouse Assistant: J. G. J. McGHEE, S.D.H. (Appointed 10/12/1958)
Paglesham —Foreman: D. T. McVITTIE.

Administration: *Secretary:* G. LESSON, B.Sc. (Econ.), A.C.I.S.
Accounts Assistant: D. A. BARTLETT.
Administrative Assistant: L. C. FITZGERALD.
Director's Secretary: Mrs. J. M. FAULKNER.
Clerical Officer: Mrs. J. BLOUNT. (Resigned 16/1/1959)
Miss D. LONG. (Appointed 16/2/1959)
Assistants: Miss G. E. A. CLACK.
Miss S. CLARKE.
Miss S. M. L. McDONAUGH.
Miss J. SHAW.

*Recognised lecturer of the University of Birmingham.





N.V.R.S. laboratory building and glasshouses, 1959.

REPORT OF THE DIRECTOR

Opening of the new laboratory building by H.R.H. The Duke of Edinburgh on Friday, 23rd October 1959

Almost exactly ten years after obtaining the site at Wellesbourne the building scheme of the Station culminated with the erection of the new laboratory building, and the occasion was marked and the Station honoured when His Royal Highness The Duke of Edinburgh officially opened this building on Friday, 23rd October 1959. On arriving at the Station at 10.00 a.m., Prince Philip, accompanied by Lord Willoughby de Broke (Lord Lieutenant of Warwickshire) and Squadron Leader John Severne (Equerry to His Royal Highness) was received by Mr. David Lowe (Chairman of the Governing Body), and the Platform Party was presented to His Royal Highness: The Right Honourable John H. Hare (Minister of Agriculture, Fisheries and Food), Sir William Slater (Secretary of the Agricultural Research Council), The Right Honourable John D. Profumo (Minister of State for Foreign Affairs and Member of Parliament for Stratford-upon-Avon), Professor T. Wallace (Chairman of the Executive Committee), Dr. James Philp, Mr. D. W. Wright, and Mr. F. W. Holder (Architect).

About 460 other persons were present, including members of the Governing Body and their wives, past members of the Governing Body, senior officials of the Agricultural Research Council and the Ministry of Agriculture, Fisheries and Food, Directors of other research stations, representatives of the University of Birmingham, members of the N.V.R.S. Association, and local civic dignitaries, officials and farmers, and members of staff and their guests.

Mr. Lowe made a brief speech of welcome to His Royal Highness and expressed appreciation of the honour he had done the Station by coming to declare the new building officially open.

Prince Philip replied and said that the Station had already done some great things in the last ten years and he hoped that the new laboratories would help it to achieve much more. At 10.15 a.m., Prince Philip officially opened the building and, after signing the visitors' book, made a tour of the building and of the glasshouses, accompanied by Mr. Lowe and Dr. Philp. During the course of the tour, senior members of the research staff were presented to His Royal Highness who showed a keen and lively interest in the 30 exhibits of research work in progress. On departing at 12.20 p.m., Prince Philip said that it had given him great pleasure to open the building and to see the research work which was being done to help growers. He also praised the exhibits and asked to have his thanks conveyed to all those who had worked so hard to make the morning such a success.

After the departure of His Royal Highness the building and the exhibits were available for inspection by all who were present at the opening ceremony. An official luncheon was held in the canteen at 1.00 p.m., where speeches were made by Mr. Lowe, Sir William Slater, Professor Wallace, Professor K. Mather, Professor H. G. Sanders and Dr. Philp.

To complete the celebrations of the day, most of the staff of the Station and their guests attended a play that evening in the lecture room. The play, 'The white sheep of the family' by L. du Garde Peach and Ian Hay, was performed by members of the staff, and this was followed by a dance.

The Station acknowledges with grateful thanks the generous grant made by the N.V.R.S. Association towards meeting some of the expenses incurred during that day. The Station is also indebted to Group Captain E. Earnshaw of R.A.F. Wellesbourne Mountford, for the loan of chairs and roping; to Luddington Experimental Horticulture Station, Pershore Institute of Horticulture and Studley College for the loan of

flowers and plants; to Miss G. Watts and Miss A. L. M. Atkinson of Studley College for the floral arrangements; to the Automobile Association for traffic direction and marshalling services; to Philips Electrical Ltd. for the recording services; and to the Warwickshire police for general security arrangements.

Grateful appreciation is also expressed to all of the staff and employees for the great amount of hard work which they carried out in order to make the day so successful.

The new laboratory building was designed by Mr. F. W. Holder, Chief Architect to the Ministry of Agriculture, Fisheries and Food. It is a two-storey building of an H-shape and has a floor area of 33,800 sq. ft. The construction uses pre-cast concrete frame and floors with external curtain walling of insulated plastic and some brickwork, the roof being of copper. In addition to laboratories and offices, it contains a library, lecture room and committee room, and a basement with space for provision of controlled-environment cabinets. The Chemistry, Physiology, Pathology and Irrigation Sections are housed on the ground floor and, on the next floor, accommodation is provided for the Entomology, Weed Control, Plant Breeding, Statistics and Administration Sections.

The transfer to the new building of equipment, etc., from the temporary laboratories and offices began when the Administration Section moved in on 1st June, and the transfer of all sections was completed by the beginning of October.

Mention must be made of the assistance given by Heads of Sections in the planning of the fixed fittings in their laboratories, by Dr. Keyworth in co-ordinating these plans, and by Mr. Winter in connection with special services required in the building.

Other development

Work was completed during 1959 on an additional 100ft. by 30 ft. glasshouse, and the brick walls, floors and drainage have been completed in the construction of additions to two existing glasshouses. A cycle shed was also erected adjacent to a store for chemicals. A portion of the boiler house (for the glasshouses) was partitioned off, and a standby generator was installed in it.

Another highlight of 1959 was the acquisition of a number of fields lying along the western boundary of the Station and amounting to 95 acres. On the recommendation of the Governing Body, this land was purchased by the A.R.C. and was leased to the Society with possession as from 29th September 1959. The addition of this land ensures that the Station will have adequate facilities for field experimental work in future. The Station, therefore, begins its second decade with 375 acres of land at Wellesbourne.

STAFF

Appointments

On 21st July 1959 Mr. T. H. Coaker was appointed as a Senior Scientific Officer in the Entomology Section in succession to Dr. R. D. Hughes. Mr. Coaker was previously employed at the Empire Cotton Growing Corporation's Research Station in Uganda.

Dr. D. J. Greenwood joined the staff as a Scientific Officer in the Chemistry Section on 1st January 1959. Previously he had been doing post-graduate research in the Departments of Biological Chemistry and of Soil Science at the University of Aberdeen.

Dr. P. J. M. Sale, who came from the University of Reading where he had been engaged in research on plant physiology, was appointed to the post of Scientific Officer in the Irrigation Section on 11th August 1959.

On 1st September 1959 Miss L. A. Kemp was appointed as a Scientific Officer in the Statistics Section.

Miss K. M. Wilson joined the staff as an Assistant Experimental Officer on 1st December 1958.

Mr. J. B. Williams was appointed as an Assistant Experimental Officer in the Irrigation Section on 1st January 1959.

On 2nd February 1959 Mr. Bernard J. Wilson joined the staff as an Assistant Experimental Officer in the Weeds Section.

Mr. R. Thompson was appointed as an Assistant Experimental Officer in the Physiology Section on 1st April 1959.

On 3rd November 1958 Mr. R. H. Mockford was appointed as Photographer.

The following 10 Scientific Assistants were appointed during the year, seven of whom replaced those who had left:—

Miss A. Carpenter, Irrigation
Temporary appointment.
Miss S. R. C. Churchill, Plant Breeding
Mrs. G. A. Dayes, Pathology
Mr. D. Goodman, Chemistry
Miss W. Hiles, Plant Breeding
Temporary appointment.
Mr. B. G. Hunt, Physiology
Miss C. A. Leadbeater, Weeds
Mr. K. Niendorf, Entomology
Miss J. Tilsley, Entomology
Miss K. Vincent, Irrigation

On 6th October 1958 Mr. W. G. Brown took up his post as Senior Farm Assistant, and on 10th December Mr. J. G. J. McGhee started work as Senior Glasshouse Assistant.

Six University students were employed during the summer to assist in the research sections.

Miss D. Long was appointed as a Clerical Officer on 16th February 1959 in place of Mrs. J. Blount.

Resignations

Dr. R. D. Hughes resigned on 31st July 1959 to take up a post in the Entomology Division of the Commonwealth Scientific and Industrial Research Organisation in Canberra, Australia.

Miss M. E. Smart resigned on 30th November 1958.

Miss B. M. Moore, Librarian, resigned on 31st May 1959 prior to her marriage.

Mrs. J. Blount resigned on 16th January 1959.

The following five Scientific Assistants resigned during the year:—
Miss C. H. Beardall, Mrs. P. A. Knibb, Miss E. A. Platt, Mrs. C. R. Slaughter and Miss C. J. Snell.

Upon completion of the new laboratory building Mr. A. C. Outram resigned from his post of Clerk of Works on 7th November 1959 to take up a post with the West Bromwich Local Authority.

Higher degree

Mr. B. Mitchell was seconded by the University of Birmingham in October 1956, under an A.R.C. Research Studentship, to carry out research in the Entomology Section for a higher degree. We congratulate him on having been awarded the degree of Ph.D. by the University of Birmingham for his thesis entitled 'Studies on the ecology of two species of the Carabidae which are probable predators of cabbage root fly eggs'. Mr. Mitchell left the Station on 31st August 1959 to take up a post with the Nature Conservancy at Aviemore, Inverness-shire.

Conferences in the U.K. and abroad

Members of the research staff attended a number of conferences during the year. In October 1958 Mr. Winter read a paper for Dr. Stanhill on 'Relative growth of foliage and roots in the carrot crop', at a joint meeting of the Association of Applied Biologists and the Horticultural Education Association. At the fourth British Weed Control Conference at Brighton in November, Mr. Roberts contributed a paper on 'Annual

weed control in established asparagus with monuron'. Dr. Spragg attended a meeting of the Society of Experimental Biology in December at which he read a paper on 'Some chemical changes associated with the induction of flowering in beetroot'. At a meeting of the British Ecological Society in January 1959, Dr. Hughes read a paper entitled 'Mortality during the egg stages of the cabbage root fly', and Mr. Wright and Mr. Maude were present at a conference on Insecticides, Fungicides and Herbicides held at Oxford in March. Dr. Spragg spoke on 'The mobilisation of betanin in beetroot' at a Plant Phenolics Group meeting in April, and Dr. Bleasdale who, with Mr. Roberts and Miss Hird attended the meeting of the British Ecological Society at Oxford, read a paper on 'Studies on plant competition'. In that month also, Dr. Hughes read a paper on 'The induction of diapause in the cabbage root fly' at the meeting of the Society of Experimental Biology held in Swansea. At the eleventh Congress of British Entomologists at Oxford in July, Mr. Wright contributed a paper entitled 'The effects of insecticides on the cabbage root fly and on its predators', and Dr. Greenwood was present at the autumn meeting of the British Soil Science Society.

Grants were kindly provided by the A.R.C. to enable members of staff to attend the following conferences. Dr. Haigh attended the general assembly of EUCARPIA (European Association for Research in Plant Breeding) held at Cologne in June. Mr. Winter took part in an International Symposium on Lysimeters held at Hannoversch-Münden, Germany, in September, at which he read a paper entitled 'Lysimetry at the N.V.R.S.'. In September also, Dr. Keyworth attended the International Botanical Congress in Montreal where he spoke on 'Silvering disease of red beet', and he also visited plant pathology departments in Canada and the United States of America.

Following a suggestion by the A.I.C. Horticulture Committee a Vegetable Seed Conference was held at the N.V.R.S. on 10th and 11th February 1959 at the request of the Wholesale Vegetable and Root Seeds Committee of the Seed Trade Association of the United Kingdom. Papers were read on methods of breeding vegetables and on the problems and methods of producing seed stocks of high quality, by members of the staff of the N.A.A.S., the N.I.A.B. and the N.V.R.S. Demonstrations were also given of the equipment and methods used at Wellesbourne in breeding and seed production work.

Lectures

During the year members of the research staff gave 24 lectures on various aspects of their research to growers, to University societies, and Young Farmers' Clubs, etc., in various parts of the country.

Mr. Nelder gave a course of 25 lectures to post-graduate students at Birmingham University on 'The design and analysis of experiments'. In November 1958 Mr. Wright gave two lectures to the final honours students of the Zoology Department of Birmingham University on 'The biology, ecology and control of certain insects of economic importance'.

Exhibit

Mr. Wright and Dr. Hughes staged an exhibit at the Royal Society's Conversazione held in London on 14th May, illustrating the natural control of the cabbage root fly.

Sporting and social activities

The first social event of the year was an autumn party held on 21st November 1958. The decorations, buffet-supper and dancing combined to make an enjoyable evening for a large number of people. An excellent Christmas lunch was served on 17th December, and was greatly appreciated by 90 members of the staff. Before Christmas also, members of the Station joined with the choir of St. Peter's Church, Wellesbourne,

in singing carols under the direction of Mr. Faulkner, who also played the church organ. The Christmas-New Year party was held on 9th January, following the traditional pattern of entertainment, with refreshments and dancing, and was enjoyed by 130 members of staff and friends. A dance was held on 20th March at the Red Horse Hotel, Stratford-upon-Avon, and the large attendance of 95 staff and guests rewarded the faith of the organisers. Several evening socials were held during the winter months when individual members of staff entertained with illustrated talks about their travels. The year's social activities ended with a summer gala on 25th July. Sporting competitions arranged for adults and children were enthusiastically supported, and Mrs. E. Glaser kindly judged the handicrafts, cookery and preserves, and Mr. P. Thoday the vegetables and floral exhibits. Later in the day Mrs. Glaser presented the prizes. For the organisation of these social functions we thank the Sports and Social Committee, Miss Dow, Mr. Durnford, Mr. George, Miss Hird (Treasurer), Miss Insall, Mr. Lesson (Secretary), and Mr. Way (Chairman).

The Stamp Club met regularly throughout the winter months, and was fortunate in having Mr. J. S. W. Cracknell give a talk about his collection of American stamps. The ladies hockey team won two of its three matches, and the two mixed matches played were both won. The mixed lawn tennis team played 13 matches, winning eight and drawing one. The table tennis club held well-supported meetings each week, and won its two matches. The cricket team lost its nine matches. This year's meeting with Long Ashton Research Station was an away fixture. The tennis match was won, and the cricket, though being lost by the narrow margin of 14 runs, added excitement to a most pleasant day.

RESEARCH

Plant Breeding

Good progress has been made in the selection of a non-bolting strain of Detroit red beet for the production of an early bunching crop.

Further trials were made of hybrids between certain selected inbred lines of the Cambridge varieties of Brussels sprouts. It was again shown that many of the hybrid families exceeded the Cambridge varieties in their yield of marketable sprouts; the greatest increase amounted to 50 per cent.

Breeding work towards the production of a variety of spring cabbage which would be suitable both for greens and for hearted cabbage was continued and progress has been encouraging.

Work with the winter cabbage variety January King has indicated that it should be possible to produce a strain which will be almost free from the defect of rosetting.

Blow-flies are now used for the cross-pollination of Brussels sprouts and of cabbages and have given satisfactory results.

An investigation on cauliflowers has shown that the early summer varieties were generally self-compatible, and that the autumn varieties and winter varieties were self-incompatible in varying degree. Knowledge of these differences can be useful in avoiding pitfalls in devising a breeding programme.

Cytoplasmic male sterility having been transferred from American material to our own onions, and second generation inbreds of the variety Cambridge No. 10 having been produced, it was possible to make a trial of hybrid lines. Unfortunately the dry summer of 1959 did not permit the natural earliness of the hybrids to show to advantage.

Nucleus stock seed of those Cambridge varieties which are on the market was again supplied to the N.I.A.B. for the production of stock seed. The stock seed will be distributed to recognised seed growers for the production of commercial seed under the scheme described in the Annual Report for 1952.

Chemistry

The three long-term field experiments have now completed the second cycle of the three year crop rotation of vegetables. On the whole the effects of the various treatments on crop production in 1959 followed the same pattern as in previous years. As before, farmyard manure produced the greatest effect on yield and it appeared that only a part of the increased yield resulted from the nutrients in the FYM. By 1959, the no-FYM plots produced symptoms of potash deficiency on early potatoes even although these plots had received an annual base dressing of phosphatic and potassic fertilisers. In the absence of FYM, applications of NP and K gave increased yields of early potatoes and red beet but in the presence of FYM it was only the nitrogenous fertilisers which gave improved yields. Results also showed that hoof and horn meal was not so satisfactory a source of nitrogen for spring cabbage as 'nitro chalk', and that this crop responded equally well to nitrogenous fertiliser in either the presence or absence of FYM.

In 1958 for the first time peas responded better to shallow primary cultivation than to deep cultivation but in 1959 shallow ploughing with subsoiling produced a higher yield of pods than either deep or shallow ploughing while shallow rotavating gave the poorest yield. For the third time in the cultivation experiment, both Brussels sprouts and leeks gave as good yields with shallow as with deep cultivation.

A field experiment with runner beans covering the three years 1957-59 showed that in the year of application, 1957, FYM itself or combined with fertiliser had an outstandingly superior effect on yield as compared with either peat or fertiliser or a combination of both. By the third season after application, however, the beneficial effect of FYM on yield had been reduced considerably, and that of peat had disappeared.

Studies were begun on the effect of oxygen concentration on the activities of soil micro-organisms which play an important part in plant nutrition. The results obtained so far indicate that a very low concentration of oxygen must be reached for the inhibition of the aerobic metabolic and nitrifying activities of the soil micro-organisms or for the induction of anaerobic metabolic and denitrifying processes.

Work elsewhere has indicated that few surface soils were capable of fixing ammonium in a non-exchangeable form, thus making it not readily available to plants and micro-organisms. All the soil series at Wellesbourne, however, have been found to possess this property and one in particular to a considerable extent.

Investigations have been continued on the chemical changes which occur in the root of red beet and especially those associated with bolting and with normal flowering. Results have been obtained which support the hypothesis that one effect of lowered temperatures on the metabolism of the roots is the replacement of anaerobic respiration by an aerobic process.

Work being done on the biochemistry of the germination of pea seeds has been extended to onion seeds. Results suggest that for normal germination of peas it is essential to have a proportion of the total sulphydryl groups on the protein molecules of the cotyledon maintained in a state of dynamic equilibrium. With onion, there is an indication that death of the seed is accompanied by an increase in the proportion of disulphide to sulphydryl groups on the protein molecules.

Plant Physiology

Studies on the competition between weeds and vegetable crops have been continued. Further work has also been done on the effects of different spacial arrangements of vegetable plants on yield. Three years' results with carrots have shown that rows spaced 12 inches apart gave superior yields to rows spaced 24 inches apart, the number of plants per square foot being the same in each treatment.

Growth studies on carrots were continued and were begun on red beet. Farmyard manure produced marked increases in the yield of both crops and, during the first five weeks of growth of the plants, produced a greater relative leaf growth rate and net assimilation rate. These effects on growth were not maintained during the

subsequent period of growth but the absolute growth rate was always greater with FYM.

Yields in a variety trial of pickling onions were low in 1959 owing to the dry season. Trials over three years showed that two varieties were consistently superior to other varieties in their yield of pickling onions which were of good shape and texture.

Black polythene film used as a soil mulch was found to improve the yield of summer lettuce. Translucent polythene and clear PVC when used in Dutch lights did not give such an early crop of winter lettuce as glass.

Irrigation

The early summer cauliflower varieties Finney's 110 and Remme were shown to produce smaller and earlier curds in consequence of having been kept dry, as opposed to moist, while being wintered in pots in frames. This confirmed previous results obtained with Finney's 110.

Irrigation experiments in the field with Finney's 110 also showed that maximum yield was very dependent upon providing a plentiful supply of water. In general, well-established plants would require two to three irrigations.

Irrigation of All the Year Round early summer cauliflower grown at four different plant spacings gave a 25 per cent increase in head weight at each spacing. Increased spacing gave increased curd size.

With the pea variety Dark-Skinned Perfection it was found that additional applications of water between sowing and flowering increased the amount of haulm but not the yield of peas, whereas an additional application of water when pods were beginning to swell increased the yield of peas.

Studies of the form and function of vegetable root systems were begun with lettuce. The characteristic form of the lettuce root system was found to be only slightly altered by varying the watering treatment.

Irrigation experiments, using oscillating spraylines, were continued in co-operation with the N.A.A.S. Experimental Horticulture Stations. In general, the irrigation treatments increased crop yields whereas they depressed them in 1958. Lettuce, however, again failed to show an increase in yield.

Studies were continued with runner beans in an attempt to discover the cause of flowers failing to set pods, and of pod shedding. It was again found that spraying of the flowers with water failed to affect the percentage of flowers which gave pods at harvest. Irrigation, however, during the dry season in 1959 increased both the number and weight of pods harvested; this effect was not produced in the wet season of 1958. Further evidence was obtained which indicated that insect pollination was necessary for early flowers to set pods.

Entomology

Field experiments during 1958 and 1959 in which there were different levels of populations of beetles (predators on the eggs of the pest, cabbage root fly) confirmed that these beetles played an important part in the natural control of the pest. They also showed that reduction in the numbers of beetles, e.g., by applying insecticides in the wrong manner, could result in greater infestations and greater crop damage than would occur naturally.

It was confirmed in 1959 that a highly effective method for the control of carrot fly in carrots was the incorporation of the insecticide dieldrin in the soil prior to sowing. It was also shown that dieldrin was very persistent in soil, considerable residues having been found more than three years after it was applied to the soil. Two new insecticides were tested against this pest.

The attack of the root aphid on summer lettuce was severe in 1959 and similar to that during 1955. An endrin seed dressing followed by an endrin spray applied to the seedlings again gave a high degree of control but better control was obtained by

incorporating endrin, thimet or diazinon in the soil before sowing. For various reasons, however, the use of diazinon is preferred for this purpose.

A study of the biology and control of the carrot-willow aphid was begun in 1959. Work was also started on the use of insecticides for the control of this pest on carrots and it was demonstrated that this insect can seriously reduce the crop yield.

Many brassica crops were severely attacked by the cabbage aphid during the latter part of the summer of 1959 and it was widely found that the effect of systemic insecticides which had been satisfactory in previous years was poor and limited. This was confirmed in experiments with Brussels sprouts and with kale at Wellesbourne. The best of a number of insecticides tested gave only partial control and this was largely due to direct contact with the pest — probably the warm dry conditions had greatly reduced their systemic action.

A sensitive bioassay method of determining the persistence of insecticidal residues in the soil has been developed and a special piece of apparatus designed and constructed for use in this work. Studies are in progress on how to obtain representative samples of soil containing insecticide from the field.

Plant Pathology

Seed treatment with the antibiotic streptomycin for the control of silvering disease of red beet is now being used by seed growers. Investigations on how the disease is spread are in progress.

The use of zinc frit at the rate of 1 lb. per sq. yard initially gave excellent control of crook root disease of watercress but later caused severe yellowing of the plants in some beds — the zinc interfering with the iron metabolism of the plants. It has since been found that zinc frit applied to only the upper half or third of a watercress bed at the rate of $\frac{1}{2}$ lb. per sq. yard controlled the disease without producing chlorotic effects.

Plants of the first backcross, *Lycopersicon esculentum* var. Harbinger x F_1 (*L. hirsutum* x *L. esculentum* var. Harbinger), produced by the Plant Breeding Section were tested for resistance to *Didymella* stem rot disease. Resistant segregates were found and the backcrossing and resistance-testing programme will be continued.

Results of field experiments in 1958 were confirmed by those in 1959 which showed that later sowings of parsnips, e.g., June instead of March, gave a reduction in the loss from canker and a higher marketable yield of somewhat smaller roots. Selection and testing has been continued on strains of parsnips showing reduced susceptibility to canker and three promising lines have been obtained.

Field experiments on the control of clubroot on summer cabbage were continued at Luddington E.H.S. The greatest increase in yield was obtained following a pre-planting dip treatment with aldrin containing a sticker.

Work has been continued on leaf and pod spot disease of peas, and on methods of control. Treatment of heavily infected seed with certain fungicides has considerably reduced the percentage of infected seeds and the treatments will now be tested on samples of commercial seed.

Studies are in progress on the *Olpidium* fungus found to be present in the roots of lettuce plants showing big vein disease.

Soil treated with zinc in the form of zinc sulphate has given good control of mildew on turnip, swede and cabbage, but not on cucumber, vegetable marrow, chrysanthemum and gooseberry despite the accumulation of zinc in their leaves. Nickel and cadmium also conferred resistance to mildew infection on turnip.

Weed Investigations

Vegetable cropping on very weedy corn land at Wellesbourne has reduced the population of weed seeds in the soil by the following amounts — first year to about half, second year to about one-fifth, third year to about one-sixth, and now the fourth year to about one-twelfth. Rotavated plots contained more seed of annual meadow grass (*Poa annua*) than ploughed plots.

Experiments have shown that numbers of weeds increased with increasing fineness of soil tilth and that rolling also increased weed numbers.

Further work has confirmed that dinoseb (amine) is useful as a residual pre-emergence herbicide with runner beans and French beans, and that simazine is useful in the same way with broad beans, spring-sown field beans and direct-sown sweet corn. A mixture of chlorpropham and fenuron also gave good weed control with broad beans and peas when applied as a pre-emergence treatment.

Three chemicals related to simazine were tested as residual pre-emergence herbicides with twelve kinds of vegetable crops. Two of them, propazine and trietazine, appeared to be promising and will be tested further, together with another promising chemical, amoben. Chlorpropham gave excellent control of chickweed (*Stellaria media*) and annual meadow grass throughout the winter in an autumn-sown onion crop.

A bioassay technique has been developed, in collaboration with Dr. K. Holly of the A.R.C. Unit of Experimental Agronomy, for the detection of small amounts of certain herbicides in the soil.

Spray drift. Studies were continued on the effects of growth-regulator herbicidal sprays drifting on to vegetables. Drift dose rates of MCPA and 2,4-D were applied to a range of vegetables at different stages of development and the symptoms and severity of injury were recorded, and the effects on yield and quality were measured.

Statistics

The Statistics Section has continued to give advice and assistance on statistical matters to the research staff, and to the N.A.A.S. Experimental Horticulture Stations and other bodies. Further work was carried out with red beet involving different cultural treatments and it was shown that the factors which affected the accuracy of field experiments were highly complicated. Under certain conditions, however, even sowing together with early weeding markedly increased experimental accuracy. Studies were also made on the growth of carrots after they had been submitted to various checks. The checks in growth were not followed by spurts of growth and so in this respect plants appeared to differ from animals.

The Director has served again on the Advisory Committees of the N.A.A.S. Experimental Horticulture Stations, and continued as Chairman of the Vegetable Working Party which co-ordinates the experimental work on vegetables at these Stations. Service was given again by Mr. Nelder on the Protected Cropping Working Party and the Vining Pea Group of the N.A.A.S., and by Mr. Winter on the Protected Cropping Working Party and on the Natural Resources Committee (Irrigation Study Group). We are grateful to the E.H.S.'s for their continued co-operation in carrying out field experiments with vegetables in extension of those done at Wellesbourne.

In seed maintenance and multiplication work and in trials of varieties, full co-operation continued between the National Institute of Agricultural Botany and this Station, and the Director again served on the Vegetable Trials Advisory Committee of the N.I.A.B.

Mr. Wright served again on the Advisory Committee and the Joint Panel of the Crop Protection Products Approved Scheme of the Ministry of Agriculture, Fisheries and Food, and on the Taint Committee of the Agricultural Improvement Council. Mr. Roberts continued to serve on the Recommendations Committee of the British Weed Control Council.

N.V.R.S. ASSOCIATION

The N.V.R.S. Association, founded in 1958, increased its membership from 111 at the end of 1958 to 164 at the end of 1959, and has acquired its first foreign member. The first Annual General Meeting of the Association was held on 3rd June 1959, when the Committee of the Association was re-elected as follows:—

Chairman of the Association: David Lowe, Esq., Elvingston, Gladsmuir, East Lothian.

Treasurer: Professor T. Wallace, 'Redwings', Old Church Road, Nailsea, Somerset.

Secretary: G. Lesson, Esq., N.V.R.S.

Committee:—

T. W. Clucas, Esq., J. L. Clucas Limited, Ormskirk, Lancs.
W. Grant Currie, Esq., Circus Street, Brighton.
E. H. Gardener, Esq., Steinbrook, Kington Langley, Chippenham, Wilts.
H. W. Hughes, Esq., The Moat House, Abbots Salford, Evesham, Worcs.
J. Jesty, Esq., Bedford and Jesty Limited, Doddings, Wareham, Dorset.
David Lowe, Esq. (Chairman).
A. McWilliam, Esq., H. J. Heinz Company Limited, Harlesden, London, N.W.10.
R. L. Scarlett, Esq., Sweethope, Musselburgh, Midlothian.
J. A. Secrett, Esq., Hurst Farm, Milford, Godalming, Surrey.
W. F. Swift, Esq., Avon Cottage, Fladbury, Pershore, Worcs.
Professor T. Wallace.
Dr. J. Philp, Director of the Station. (Ex officio).

After the business meeting, members were conducted round experimental plots and shown the various aspects of research being carried out on cauliflowers. It was not possible to hold a Members' Day during the autumn because the staff were involved in the additional work of transferring equipment, etc., to the new building, and were making preparations for the official opening by His Royal Highness The Duke of Edinburgh on 23rd October 1959. Members, however, received an invitation to attend the ceremony (more than 50 were present) and they then had an opportunity of inspecting the exhibits prepared by the different sections of research.

This link between practice and research is of benefit both to members and to the Station staff, and we look forward, therefore, to more people becoming members of the Association. Members receive each year a copy of the Annual Report of the Station and, so long as they are available, they may obtain reprints of papers written by the staff, and are entitled to attend all members' days: three have been arranged for 1960. Forms of application for membership and copies of the rules of the Association may be obtained from the Secretary of the Station.

Visitors

The number of visitors to the Station during 1958-59 was 859, including the following from overseas:—

Australia:	Dr. N. C. Crowley, The Waite Institute, Adelaide.
	Mr. B. A. B. Edwards, Senior Entomologist, Merrindale Research Station, Croydon, Victoria.
	Mr. D. L. Jones, Shell Chemical (Australia) Pty. Ltd., Brisbane, Queensland.
	Mr. W. R. Meadly, Department of Agriculture, Western Australia.
Ceylon:	Mr. S. Nagmuthu, Department of Agriculture, Peradeniya.
	Mr. D. A. Nethsinghe, Coconut Research Institute.
	Mr. E. S. Rajiah, Gonakelle Estate, Passara.
	Mr. P. N. S. C. Wijewarnasuriya, Experimental Farm, Department of Agriculture, Peradeniya.

Finland:	Three Journalists from Massey-Ferguson Ltd., Helsinki.
Germany:	Professor K. O. Müller, Heidelberg.
Ghana:	Mr. C. J. Langley, University College of Ghana.
Holland:	Dr. J. I. Bierhuizen, Institute of Land and Water Management, Wageningen.
India:	Mr. S. S. Chadha, Assistant Plant Protection Officer, Department of Food and Agriculture, Rajasthan, Jaipur. Mr. S. Das, Assistant Mycologist, Crop Protection, Bhubaneswar. Mr. G. M. Hingorani, Plant Protection Officer, Ministry of Agriculture, Fisheries and Food, New Delhi. Mr. M. B. Raizada, Forest Research Institute, Dehra Dun. Mr. S. P. Rao, Plant Protection Assistant, Agricultural Department of State Government, Andhra Pradesh, Hyderabad. Mr. A. R. Thapar, Horticultural Officer, Himachal, Simla. Mr. A. Varghese, Plant Protection Assistant, Agriculture Department, Kerala.
Indonesia:	Mr. R. I. Martalogawa, Shell International Chemical Co. Ltd., Djakarta.
Japan:	Mr. M. Fukaya, National Institute of Agricultural Science, Tokyo. Mr. Y. Hamada, Yasugawa Pesticides Plant, Sankyo Co. Ltd., Tokyo.
Kenya:	Mr. D. C. Attenburrow, Horticultural Research Station, Thika.
Malaya:	Mr. Boey Kok Chong, Imperial Chemical Industries Ltd.
Malta:	Mr. J. Debrincat, Department of Agriculture, Valletta.
New Zealand:	Mr. R. M. Moffat, Horticultural Research Officer, Birds Eye Foods. Mr. L. W. Tiller, Department of Scientific and Industrial Research, Wellington.
Nigeria:	Chief Mallam Ado Bayero, Kano. Mr. D. A. Lawes, Empire Cotton Growing Corporation. Mr. J. M. A. Sly, West Africa Institute for Oil Palm Research.
Pakistan:	Mr. A. R. Khan, Dacca Farm.
Poland:	Mr. M. M. Manczak, Vegetable Research Station, Skierniewice.
Sierra Leone:	Mr. H. D. Tindall, Department of Agriculture, Freetown.
South Africa:	Dr. A. Joffe, University of Pretoria.
Southern Rhodesia:	Mr. J. L. Manson, Salisbury. Mr. W. J. Bassett, Department of Conservation and Extension.
Sweden:	Dr. H. Christensson, Vällingby.
Tanganyika:	Mr. S. L. Kaaya, Usa River.
Thailand:	Mr. A. Aphirat, Assistant Entomologist } Bangkhen Experimental Mr. P. Sothorn } Station.
Turkey:	Mr. P. Baysal, Agricultural Research Station, Istanbul. Mr. N. Kaskaloglu, Director, Plant Protection Institute, Izmir. Mr. A. R. Leventoglu, Phytopathologist, Plant Protection Service, Samsun.
U.S.A.:	Mr. D. G. Cuthbertson, Ferry-Morse Seed Company, Detroit, Michigan. Dr. J. H. Ellison, Rutgers University, New Brunswick, New Jersey. Miss N. Gundrey, Cornell University, New York. Dr. L. L. Harrold, United States Department of Agriculture, Ohio. Professor A. Naylor, Duke University, North Carolina. Dr. G. S. Pound, University of Wisconsin, Madison. Professor W. A. Rawlins, Cornell University, New York. Party of American Horticulturists, organised by the Travel Service Bureau Inc.
Yugoslavia:	Ing. D. Buturovic, Sarajevo. Ing. R. Vukcevic, State Farm, Croatia.
Iran:	Mr. A. Dezfoulian, Deputy Director, Veramin Research Station, near Teheran. Dr. Y. Fuizat, Director of the Multipurpose Vocational Teacher Training School, Mamasan, Veramin, near Teheran. Mr. E. Naraghi, Department of Plant Protection, Ministry of Agriculture, Teheran.
Italy:	Dr. F. Favati, Shell Chemical Company (Italy). Ing. A. Mandriota, Bari. Dr. G. Marini, Secretary General to the Verona International Fair, Verona. Professor A. Modens, Agrarian Inspector, Genoa. Professor A. Panattoni, Institute of Agrarian Economy, University of Pisa. Professor G. Priorelli, Director of the International Centre of Agricultural Mechanisation, Torino.

Philippines:	Mr. P. T. Iral, Senior Plant Pest Control Officer, Bureau of Plant Industry, San Andres, Manila.
	Mr. R. B. Valdez, University of Philippines, College of Agriculture, Laguna.
	Mr. O. C. Villasenor, Central Luzon Agricultural College, Nueva Ecija.
Zanzibar:	Mr. M. A. Ghassany, Department of Agriculture.

In addition, the following 22 parties visited the Station:—

1958	
1st October	Members of the Association of Rural District Council Surveyors (Midland Region).
1959	
22nd April	Members of the Association of British Organic Fertilisers (Inc.).
20th May	Professor A. H. Bunting and students from the University of Reading.
27th May	Members of the Wolvey Young Farmers' Club: Members of the Tysoe and District Young Farmers' Club: Dr. P. Murphy and students from the University of Nottingham, School of Agriculture, Sutton Bonington.
28th May	N.A.A.S. Officers (South-eastern Region).
11th June	Barston and District Young Farmers' Club.
16th June	N.I.A.B. Variety Trials Advisory Committee.
24th June	Members of the Retail Seed Trade Association. Dr. T. Walsh and a study group from the National Research Station for Glasshouses and Vegetable Crops, near Malahide, Dublin.
30th June	Members of the N.F.U. Headquarters Vegetables Committee.
1st July	N.A.A.S. (South-western Region).
2nd July	N.A.A.S. Soil Chemists.
3rd July	British Council Course on Plant Breeding and Crop Improvement.
7th July	Staff and students from the City of Coventry Training College.
20th July	Mr. H. Fraser and a party of students from the Department of Horticulture, The University of Reading.
21st July	Students from Studley College, Warwickshire.
22nd July	Members of the Pailton Young Farmers' Club.
30th and 31st July ...	N.A.A.S. Horticultural Advisory Officers.
12th August	Dr. C. E. Harrold and students of the Department of Botany, The University of Birmingham.
19th August	Members of the South-Holland Growers' Club.

Acknowledgments

Certain members of the staff have carried out duties in addition to their normal work, and special thanks are given to them. Particular mention is made of the following committees which have given the Station valuable service: Canteen Committee—Mr. Cleaver (Secretary), Dr. Keyworth (Chairman), Mr. Lesson (Treasurer), Miss Slade, Mr. Winter and, upon the resignation of Miss Moore, Miss Lievesley who was co-opted to this Committee; Glasshouse Committee—Dr. Haigh, Dr. Keyworth, Mr. Norwood, Mr. Winter and Mr. Wright (Chairman); Library Committee—Dr. Haworth, Miss Moore, Mr. Nelder and Mr. Roberts (Chairman). Mrs. George and Mr. Roberts are thanked for carrying out library work during the absence of a librarian, and Mr. Nelder is also thanked for assisting in the editing of this Annual Report.

Thanks are also due to other members of the staff who helped in various ways and to all the staff and employees for the loyal manner in which they carried out their work.

Grateful acknowledgment is made to the Executive Committee and the Sub-Committees and, particularly, to the Chairman of the Governing Body, and the Chairmen of the Committees for the assistance they have given.

Thanks are due to the Rockefeller Foundation of New York for providing the Station with a grant, through the A.R.C., for the purchase of a 'Spinco' ultracentrifuge. This special piece of equipment will be a great asset in the virus research work being carried out in the Plant Pathology Section.

Gifts to the library which are gratefully acknowledged include 32 volumes of 'Scientific Agriculture' from the Canada Department of Agriculture and volumes of two scientific journals and a large collection of reprints from Dr. Nelson of the University of Edinburgh.

To all our friends outside the Station, particularly growers and commercial firms, who have kindly given seeds, plants and other material, and who have helped in so many ways during the year, we extend our grateful thanks.

J. PHILP,

19th *February* 1960.

FARM

By T. J. NORWOOD

Wellesbourne

After a mild, wet winter growth in the spring of 1959 was rapid. Although we were later than usual in getting seed sown, germination was good and the young cereals soon became well-established. The grass growth was so forward that it was possible to turn the bullocks on to the River Meadows a fortnight earlier than usual. Grass cutting for silage began on 9th May and the first hay was cut on 23rd May. About 100 tons of silage and 55 tons of good quality hay were safely stored in the Dutch barn by mid-June. However, the conditions so favourable for hay making and harvesting were not so favourable for further grass growth and no more silage or hay could be made after June.

With ample moisture reserves in the soil the early vegetable crops grew well and good crops of autumn-sown and early spring-sown peas were harvested but later planted crops and main crop potatoes suffered from the prolonged dry weather, except where it was possible to irrigate. Under irrigation the yields of beetroot and carrots sown at the end of June were exceptionally high.

The winter wheat sown during the second week in October over-wintered well and produced an excellent crop, which was awarded third prize in the cereal growing competition organised by the Stratford-upon-Avon Branch of the National Farmers' Union. The yields of barley varied a good deal, the early-sown crops giving much the better yields.

In the autumn 75 Hereford cattle were bought and were yarded for the winter months; 33 were graded from the yards and 42 were turned out to grass in early April. Of these, 32 were graded during the summer, the remaining 10 being retained for yarding in 1959-60. The herd of Large White pigs was maintained during the year and from 32 litters born, 249 pigs were reared. Most of these were sold for bacon, but some of the best were retained for herd replacements, or were sold for breeding.

It is estimated that about 600 tons of farmyard manure was produced and ploughed into the vegetable fields during the year.

Paglesham

Crops of Brussels sprouts and onions were grown for seed production in 1959 and for selection of stock plants for seed production in 1960. Harvesting conditions were ideal for both crops and a quantity of good quality seed was obtained. A good crop of bulb onions was also harvested from which selections will be made for next year's seed production. From mid-summer onwards aphis infestations were troublesome and the sprout crop had to be sprayed four times to keep the pest under control.

The corn crops were very satisfactory and the yields of straw and grain were good but the potato yield was considerably below normal. The hay crop was heavy and was well saved but, in the absence of rain, the growth from mid-summer onwards was poor and there was little aftermath for grazing and none for making into silage.

Thirty-two young cattle bought in the autumn of 1958 were over-wintered in the covered yards. All went out to grass in April and half of them were graded for beef during the summer. The remainder will be fattened in the yards this winter and will be graded for beef as and when they reach prime condition. These, together with the herd of Large White pigs, supplied about 200 tons of farmyard manure for ploughing into the vegetable plots.

PLANT BREEDING REPORT

By J. C. HAIGH

BREEDING PROJECTS

In addition to the work reported below, progress has been made towards breeding early maturing, winter-hardy peas, early summer cauliflower of better quality, all-male asparagus, lettuce resistant to mosaic virus, tomatoes resistant to *Didymella*, and self-blanching celery of improved quality. Details of this work will appear in future reports.

Red beet (H. Holland and G. J. Frost)

The progress made in the selection of a non-bolting strain of Detroit beet by the method previously described (1) was tested during 1959. Nine breeding lines which had been selected against bolting for two successive generations, and three lines which had been selected once, were compared with two unselected (control) lines. The trial was done in two parts. There was insufficient seed to allow of every line being represented in each part, but ten of the lines (seven twice-selected, two once-selected and one control) were common to both parts.

In the first part of the trial, seed was sown early in January in the glasshouse and the seedlings were grown in continuous light from 1st–22nd February — to encourage bolting. They were then grown in normal daylength, still in the glasshouse, until transplanted to the field on 1st April. They were planted out in four randomised blocks each of 12 plots with 100 plants per plot. The 12 plots contained nine twice-selected lines, two once-selected lines and one unselected control.

Bolters were recorded in the control plots during the first week of May and almost every plant had bolted by the beginning of June. At this date, the two once-selected lines had respectively 60 and 8 per cent bolters, but the nine twice-selected lines had a mean of only 1.8 per cent. On 8th June, half of each plot was harvested as for the early bunching market. No significant differences were found between means of root weight, root diameter or leaf weight, but there were marked differences in quality. The roots of the twice-selected lines showed no rings on cutting, the control line was distinctly ringed and the once-selected lines were intermediate. Bolting records were taken at weekly intervals until 21st August. The two once-selected lines had bolted completely by 22nd June and 21st August; of the nine twice-selected lines, one had bolted by 6.3 per cent and the others by between 25-53 per cent when the last records were taken.

In the second part of the trial, direct field sowings were made on 13th March of seven twice-selected lines, three once-selected lines, and two unselected lines as controls. There were again four randomised blocks each of 12 plots but with 120 plants per plot. The first bolters appeared in the control plots during the second week of May; all plants of one control line had bolted by 6th July and of the other by 27th July. In the once-selected lines, bolters were recorded on 26th May; one line had bolted completely by 27th July, and the others had 93 and 49 per cent bolters by 21st August when the last records were taken. No bolters had appeared in any of the twice-selected lines by 22nd June, when the second bunching crop for market might have been taken. The first bolter in any of these lines was recorded on 6th July, and at the end of the recording period, three lines had bolted less than 2 per cent, one 2.7 per cent and the remaining three between 6 and 9 per cent.

There is no doubt that the incidence of bolting can be reduced by selection, but it is not so certain that it can be eliminated altogether by this method. The bolting reaction is probably controlled polygenically, and hence it is not surprising that there have been one or two discrepant results, e.g., one progeny bolted to a greater degree than either of its parents. However, even these lines had shown little bolting by the

time they would normally have been lifted for the bunching market, so that from the practical point of view it is possible to reduce the amount of bolting on early sowing to negligible proportions by two or perhaps three generations of selection under conditions which encourage bolting.

Brussels sprouts (A. G. Johnson and G. J. Faulkner)

During the summer drought in 1959 growth was considerably retarded, and aphis was especially troublesome and complete control by insecticide was not obtained. Where plants from the same packet of seed were grown in both 1958 and 1959, yields were found to be 20 to 25 per cent lower in the latter year than in the former.

The results of test crosses between inbred lines in previous years, coupled with study of the inbred lines themselves, made it possible to discard some of the lines. In consequence, it was feasible in 1959 to test complete diallel series of crosses, instead of samples of the many possible crosses as in previous years.

The first trial was of hybrids between selected plants of four different S_3 lines of Cambridge Special, two of which carried the male sterility factor (3). One of these combinations failed to set sufficient seed to enable it to be included in the trial. Of the five hybrid families grown, the best gave a yield equivalent to 5.9 tons per acre of marketable sprouts, which was 50 per cent better than that of the parent variety. Three others beat the parent variety by 30 per cent and one by 16 per cent. In all the hybrids, the sprouts were more uniform in size than in the parent variety.

The second trial was of hybrids between selected plants of six different S_2 lines of Cambridge No. 3. Of the 15 hybrid families tested, seven gave a greater yield than the parent variety. At a spacing of 3 ft. square the best hybrid family gave a yield equivalent to 5.4 tons per acre of marketable sprouts, which was 25 per cent better than that given by the parent variety.

The third trial was of hybrids between the S_3 plants of Cambridge Special which produced the hybrids in the first trial, and the S_2 plants of Cambridge No. 3 which produced the hybrids in the second trial. Of the eight hybrid families tested, four gave a greater yield than the higher-yielding parent variety, Cambridge No. 3. At a spacing of 3 ft. square the best of these hybrid familes gave a marketable yield equivalent to 5.5 tons per acre, which was 34 per cent better than that of Cambridge No. 3, and 46 per cent better than that of the mean yield of marketable sprouts of the two parental varieties.

S_4 lines of Cambridge Special were grown, which were derived by self-pollination from the same S_3 plants as were used for combining to produce the hybrids in the above trials. In addition, S_4 lines derived from S_3 sibs of these plants were grown. The S_4 lines were very uniform so that in one of the good quality lines there was no difficulty in finding 60 plants, each of equally high standard, out of 140 plants grown. Small but commercially important differences occurred, however, between S_4 lines derived from sibs in the S_3 generation thus showing that segregation for characters of commercial importance was still taking place.

The hybrid plants tested in these and similar trials have been grown from seed produced in small quantity by hand or blow-fly pollination. Before the benefits of hybrid Brussels sprouts can be enjoyed by the public, ways must be found of producing hybrid seed on a commercial scale, and these problems may present more technical difficulties than those which have already been overcome. Work is in hand to compare the merits of various methods of producing hybrid seed under field conditions.

Spring cabbage (A. G. Johnson and G. J. Faulkner)

In the 1956-57 season, further plants were selected for use in the breeding programme, from nine varieties found to be superior in previous trials. Plants were also selected from eight new varieties grown for the first time at Wellesbourne and found to be promising. These plants were selfed and also pair-crossed both within and between varieties, and the progenies were grown in 1958-59. Four varieties gave consistently superior progenies, whether produced by selfing or pair-crossing. The

best individual progeny (resulting from self-pollination) was ready to cut as partially-hearted spring greens about two weeks before any other; it had a dark green colour and was free from bolting. The hearts remained small and were still fit to market as hearted cabbage 4-5 weeks later. Plants have been selected from several progenies for further breeding work.

Winter cabbage (A. G. Johnson and G. J. Faulkner)

Progeny tests of January King cabbage in the seasons 1957-58 and 1958-59 showed that the incidence of rosetting varied considerably between different progenies. There were also differences in both colour and size of heart. Plants selected from the progenies with medium-small hearts and least rosetting were selfed and also pair-crossed both within and between progenies. The families derived from the 1957-58 selection are being grown in 1959-60 and again show varying amounts of rosetting. The best family, resulting from self-pollination, had no rosettes in 73 plants and was also good with respect to size, shape and colour. Plants have been selected from several families for further breeding work towards a somewhat smaller type of January King with less rosettes.

Cauliflower (L. E. Watts)

Studies on the breeding system of cauliflowers have indicated that the early summer types were generally self-compatible, while the autumn and winter types were self-incompatible in varying degree both within and between varieties. The degree of compatibility was determined in two ways; first by self-pollinating flowers on one branch of an inflorescence and pollinating unemasculated flowers on another branch of the same inflorescence with pollen of Brussels sprouts, with which cauliflower is completely cross-compatible; and secondly by surrounding cauliflower plants with Brussels sprout plants in the field and relying on natural pollination. The cauliflower plants used in the field trial were vegetative propagants of those pollinated in the glasshouse.

Summer cauliflower varieties treated as above gave no more seed per pod when crossed than when selfed, and there were few hybrids in the progeny from the branch on which the flowers had been brushed with Brussels sprout pollen. Winter cauliflowers, on the other hand, gave more seeds per pod on crossing than on selfing, and the progeny from the crossed branch had a high proportion of hybrids. Nevertheless, even the most self-compatible variety did not give a full seed set on selfing, and the most self-incompatible variety did set some selfed seed. The winter cauliflower variety Cambridge Dwarf April was found to be exceptional in that it was self-compatible while the variety from which it was selected by Boyes was found to be self-incompatible to a high degree. The unusual uniformity of Cambridge Dwarf April is no doubt a result of its being self-compatible.

Onions (H. Holland and G. J. Frost)

A preliminary test of hybrid material has been made to allow the rate of progress of the breeding programmes to be assessed, since we have no information on the amount of inbreeding needed to give optimum results. First, the male-sterile character was transferred from American material to the seedling line K_1 by two generations of back-crossing with K_1 as the recurrent parent. Next, these male-sterile K_1 lines were crossed with second generation inbreds of the variety Cambridge No. 10. Nine hybrid lines and six inbred lines of No. 10 were tested against out-pollinated K_1 and No. 10 in four randomised blocks in which each plot was sown with 400 seeds (equivalent to 5 lb. per acre). The control plots of K_1 and No. 10 were sown at three seed rates to allow of corrections for stand.

Hybrid seedlings emerged some seven days before the inbred male parents and some three days before the controls; germination was also appreciably better and at

harvest the mean stands in the plots of different origins were in the ratio hybrids: controls:inbred male parents=1.6:1:0.5.

The long dry summer of 1959 ripened the bulbs early, particularly the hybrids which were completely dried-off by 6th August. A small amount of rain during that month helped the late-maturing male parents and controls to put on a little more growth, but the whole trial had been harvested by the first week of September.

Three of the hybrid lines were better than either out-pollinated control in actual yield, but not when yield had been corrected for stand. Differences in yield between hybrids having a parent in common indicated the need for comprehensive tests of combining ability. The dry season not only reduced all yields by ripening the bulbs early, but favoured the later-maturing lines (including the controls), by eliminating the unmarketable bulbs which occur in an average summer.

Clubroot resistance in brassicas (J. C. Haigh and E. Miriam Slade)

Mention has been made in the seventh (2) and subsequent Annual Reports of facilities provided in the form of infected land at the Luddington E.H.S. for observing the incidence of clubroot caused by *Plasmodiophora brassicae* Woron. on some cabbage varieties. The reliability of the results of field tests of material heterozygous for resistance depends on having field plots uniformly — and preferably heavily — infected, and the work of the last three years has been directed mainly towards locating accurately such plots, and building up the level of infection by ploughing in any susceptible material grown on them. Obviously, during this period, accurate comparisons of the degree of resistance of cabbage varieties has been impossible; at the same time, the consistency of differences between the degree of infection of experimental material and of susceptible controls, when grown on the infected area, indicate that these differences are due at least in part to differences in resistance, and are not merely reflections of the irregular distribution of the clubroot organism in the soil. We now hope to be able to make more accurate comparisons of test material under field conditions. The material in which resistance has been found is derived from two German varieties supplied by the Horticultural Plant Breeding Institute, Wageningen, and also from material supplied by Dr. J. C. Walker of Wisconsin. Plants of all these resistant lines have been interplanted with susceptible Primo as control. At maturity, root systems have been examined and graded for degree of infection by clubroot, and plants showing little attack have been kept for seeding. In all this work, we have had the very willing co-operation of Mr. A. G. Channon of the Pathology Section.

Blow-fly pollination of brassicae (G. J. Faulkner)

Blow-flies are now in regular use for cross-pollination of Brussels sprouts and cabbage, both in nylon cages and in cellophane isolation bags. They are readily available from commercial sources, are more easy to handle than bees, and have given seed sets as good as or slightly better than those from hand or bee pollination. A more detailed report of technique and results is in preparation.

Lettuce (L. E. Watts and R. A. T. George)

The artificial production of lettuce hybrids is technically difficult. The capitulum, or flowering head, has a large number of small flowers which are open for only a short time, and the floral mechanism greatly favours self-pollination. Emasculation is both difficult and uncertain of result, and the method recommended by American workers, of removing the pollen from the anthers by the use of a fine jet of water, has not been successful under our conditions. Consequently, a chemical which has been successfully used as a gametocide on cotton in the U.S.A. has been tested on lettuce and has given encouraging results.

SEED PRODUCTION

Nucleus stock seed was produced of the following varieties in 1959:—

Brussels sprouts	..	Cambridge Special at Paglesham.
Onion	.. ..	Cambridge No. 10 at Paglesham and Wellesbourne.

Plants were grown of the following varieties to produce nucleus stock seed in 1960:—

Brussels sprouts	..	Cambridge Special at Paglesham.
Onion	.. ..	Cambridge No. 10 at Paglesham and Wellesbourne.

WORK AT OUTSIDE CENTRES

Spacing trials with two quick-freeze Brussels sprout varieties were planted at Efford, Luddington and Stockbridge E.H.S's. Facilities were again provided at Luddington E.H.S. for observing the incidence of clubroot on some cabbage varieties. To the Directors and staffs of these stations we offer our thanks. In consultation with the Director of Rosewarne E.H.S. and the Director of the N.I.A.B., a breeding programme was drawn up for the improvement of Roscoff broccoli varieties.

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CHEMISTRY REPORT

By F. HAWORTH

FIELD EXPERIMENTS

In March and early April 1959 the soil of the experimental area was very wet and it was difficult to prepare a satisfactory tilth for the planting of early potatoes and summer cabbage. During the almost rainless summer all the experimental crops were irrigated, either to get them well established or to prevent them from dying from lack of water. Good yields were obtained of all crops with the exception of summer cabbage which grew very slowly in April and May and failed to produce cabbage of marketable quality. The poor physical condition of the soil, resulting from the wet winter of 1958-59, is considered to have been the cause of this failure. The results of measurements made on soil samples taken from the plots in early July, showed that the soil was compacted and that the percentage of non-capillary pore space (a measure of aeration) was much lower than that generally considered to be necessary for satisfactory plant growth.

Cultivation experiment

Deep ploughing, shallow ploughing with subsoiling, and shallow ploughing alone did not differ in their effects on the yields of leeks (harvested December 1958) and of spring cabbage (harvested April 1959) but gave higher yields than shallow rotavating as a primary cultivation. Shallow ploughing produced a higher yield of Brussels sprouts (harvested November 1958 to February 1959) than the other primary cultivations but the difference was small and was not statistically significant. Shallow ploughing with subsoiling produced a higher yield of peas than either deep or shallow ploughing, while the three ploughing treatments produced greater yields than shallow rotavating.

As expected, plots which had received only nitrogenous fertilisers since 1954 produced much smaller yields of the four crops than plots which had received annual applications of FYM together with phosphatic and potassic fertilisers over the same period. There was, however, an interesting interaction between fertiliser treatment and the type of primary cultivation. In general, shallow rotavating produced smaller yields than the three ploughing treatments but the difference in yield was much greater when nitrogenous fertilisers were applied alone than when the crops were fully manured.

Nitrogen experiment

As mentioned earlier in this report, the summer cabbage crop failed. The leeks had not been harvested at the time of writing. The responses of early potatoes to the different nitrogen treatments followed the same pattern as in previous years. Hoof and horn meal and nitrochalk, in equivalent quantities of nitrogen, produced about equal yields: one application of nitrochalk (treatment N_1) at planting time produced a greater yield than the same total amount of fertiliser divided into four doses (treatment $4N_4$) and applied at intervals during the growth of the crop. The response to FYM was greater than in previous years. Symptoms of potash deficiency were seen on the plants on the no-FYM plots in late May and the results of the chemical analysis of the leaves confirmed that, as in 1958, the plants were suffering from potash deficiency.

Hoof and horn meal again produced much lower yields of spring cabbage than the equivalent amount of nitrogen given as 'nitrochalk' especially in the absence of FYM, and it is clear that hoof and horn meal is not a suitable source of nitrogen for the spring cabbage crop. In the presence of FYM, treatment N_1 produced a lower yield

of cabbage than treatment $4N_{\frac{1}{2}}$, but in the absence of FYM the two treatments produced almost equal yields.

NPK-FYM factorial experiment

The four crops in the rotation of early potatoes, spring cabbage, carrots and red beet, showed large increases in yield attributable to applications of FYM. In the absence of FYM, applications of each of the three major nutrients produced increases in the yields of early potatoes and red beet, but in the presence of FYM, only nitrogenous fertilisers gave rise to improved yields of the two crops. Applications of potash fertilisers produced increases in the yield of carrots but only in the absence of FYM. Spring cabbage showed very large increases in yield attributable to applications of nitrogenous fertilisers and the reponse was the same in the presence and absence of FYM. A comparison of the yields obtained from plots which had received the highest rates of application of the three mineral fertilisers, with those from plots which had received similar applications of fertilisers, together with FYM, indicates that, while a part of increase in yields attributable to FYM may be ascribed to its nutrient content, by far the larger part of the increase must be ascribed to other effects of FYM.

Following the observation by Austin (1) that the growth rate of small seedlings may be important in determining the ultimate yield of a crop, measurements have been made of the uptake of nutrients by carrot and red beet seedlings in the first 20 days after emergence. The results show that, even at seven days after emergence, the cotyledons of plants growing on the +FYM plots contained about twice as much potassium as those growing on the no-FYM plots, but that the phosphorus and nitrogen contents of the two groups of plants were not appreciably different.

Runner beans

The experiment (10), started in 1957, to measure the response of runner beans to soil physical conditions and nutrient supply, was continued. Six treatments were applied in 1957: zero, FYM (30 tons per acre), peat (about eight tons per acre giving five tons organic matter per acre), fertiliser (150 lb. N, 60 lb. P_2O_5, 240 lb. K_2O, each per acre), peat with fertiliser, and FYM with fertiliser. No fertilisers or organic manures were applied in 1958 but two of the four replicates of the experiment were limed at the rate of two tons per acre of ground limestone. In 1959, plots which had received fertilisers in 1957 were given a fertiliser application which supplied 60 lb. N, 36 lb. P_2O_5, 96 lb. K_2O, each per acre. The yield results obtained are shown in Table I.

TABLE I

Yield of runner beans. kgs. per 4×20 sq. yard and as a percentage of the control yield

Treatment	No fertiliser			Fertiliser		
	1957	1958	1959	1957	1958	1959
Zero ..	24.2 (100)	42.2 (100)	37.9 (100)	84.9 (351)	121.6 (288)	110.4 (291)
Peat ..	38.6 (159)	54.8 (130)	32.2 (85)	109.8 (453)	145.1 (344)	117.2 (309)
FYM ..	189.6 (593)	145.4 (345)	91.3 (241)	200.4 (828)	164.4 (390)	135.0 (356)

The fertiliser treatment produced marked increases in yield in each of the three years. The incorporation of peat produced an appreciable increase in yield in 1957 both in the presence and absence of fertiliser, but the residual effect of the peat as measured by the yield of beans was small, and had disappeared by 1959. The FYM

treatment produced a higher yield of beans than did the peat treatment and, although the percentage increase in yield over the control yield was greatest in the year of application and was about the same in the presence as in the absence of fertiliser, the residual effect of the FYM was still considerable in 1959. The residual effect of FYM (without fertiliser) in 1959, however, was not as great as the effect of fertiliser alone. If the difference in yield between the fertiliser only, and the FYM with fertiliser treatments was mainly the result of an improvement in the physical conditions of the soil of the FYM treated plots, it appears that the improvement was of relatively short duration. The results of other long-term field experiments with vegetables at Wellesbourne also showed that the immediate effects of FYM were of more importance in crop production than its long-term or residual effects.

THE EFFECT OF OXYGEN CONCENTRATION ON THE ACTIVITIES OF SOME SOIL MICRO-ORGANISMS (D. J. Greenwood)

The problems of predicting the fertiliser requirements of soil and of explaining the dependence of plant growth on the physical condition of soil, have made necessary fuller investigations into the activities of the soil micro-organisms. The physical condition of soil greatly influences the supply of oxygen to the micro-organisms, thus affecting their activities and in consequence the amount of plant nutrients in soil. The immediate objects of the present work are to determine the effects of oxygen concentration on the activities of the soil micro-organisms and to determine the distribution of oxygen in soil.

Any oxygen required by the micro-organisms travels first through the soil atmosphere and then through the soil water to the microbial surfaces. Since oxygen diffuses 10,000 times faster through air than through water, there are always large variations in the oxygen concentration in the soil water and only small variations in oxygen partial pressures in the soil atmosphere. It is, therefore, the oxygen concentration in the soil water on the surfaces of the micro-organisms that should be correlated with their activities. This oxygen concentration, which can only be measured indirectly, is a function of the thickness of the soil water film through which the oxygen must travel, the rate of oxygen uptake by the micro-organisms, and the partial pressure of oxygen in the soil atmosphere. A technique for measuring these quantities simultaneously with the measurement of the microbial activities has been developed.

Different microbial processes have been studied using techniques similar to the one described below for studying nitrification (the microbial conversion of ammonia to nitrate). The activity of nitrifying organisms was stimulated in soil crumbs by continually percolating the crumbs with 0.01 molar ammonium sulphate whilst the air in contact with the soil was maintained at a constant oxygen partial pressure. Estimations were made of: (a) the rate of oxygen uptake; (b) the oxygen concentration on the surface of the crumbs; (c) the nitrate in the percolating solution; (d) the distribution of micro-organisms; and (e) the average radius of the soil crumbs. An electrolytic rocking percolator (6, 7) was designed to facilitate estimations of (a), (b) and (c); (d) was obtained by techniques described elsewhere (8), and (e) was obtained by direct measurement.

The results obtained so far appear to indicate that neither the aerobic metabolism of organic compounds nor nitrification was inhibited through lack of oxygen unless the oxygen concentration was less than about 14×10^{-5} ml. of oxygen/ml. of water. The anaerobic metabolism of organic compounds and denitrification did not appear to be induced until equally low oxygen concentrations were reached. It may be deduced from these results that if water-saturated crumbs are larger than about 0.35 cm. radius their centres will contain no oxygen. This may be the explanation why crumbs of about this size are the largest permitted in a John Innes compost. It is hoped in future experiments to investigate the potentialities of using the soil micro-organisms as indicators of oxygen concentration and thus to determine the distribution of oxygen in a soil under field conditions.

FIXATION OF AMMONIUM BY WELLESBOURNE SOILS (D. J. Greenwood)

During the course of experiments on nitrification, it was found that if a solution containing ammonium was added to a soil of the Wyre series from the Water Meadows on the Station, it was not possible to recover the added ammonium by extraction with 0.5 molar potassium sulphate. Since this reagent completely extracts exchangeable ammonium (2, 4, 5) it seemed possible that this soil could fix an appreciable quantity of ammonium thus rendering it not exchangeable and not easily available to plants and micro-organisms (9, 11). Work at Rothamsted (2, 3) suggested that only a few surface soils were able to fix ammonium under moist conditions so that it was of interest to find out whether soils of other series on the Station possessed this property.

Determinations of ammonium fixation were made by Nommik's method (11) with the modification that 0.5 molar potassium sulphate instead of 0.5 molar potassium chloride was used for extraction. Ammonium fixation is expressed as milli-equivalents of ammonium/100 g. of soil resulting from 48 hours treatment of 10 g. of oven dry surface soil (0-9 inch) with 10 ml. of a solution containing 0.5 milli-equivalents of ammonium.

TABLE II

Site	Soil Series	Ammonium fixation	Soil use
Big Cherry Ground..	Newport (normal phase)..	0.17	Arable
Big Ground	Wick (light)	0.27	,,
Gallas Leys	Spetchley (medium) ..	0.55	,,
Soakwaters	Spetchley (heavy) ..	0.32	,,
Soakwaters	Wick (heavy)	0.34	,,
Water Meadows ..	Wyre	1.14	Permanent pasture
Wellesbourne Gravel Pits ..	Newport (gravel phase)	0.22	Arable

Table II shows that all the Wellesbourne soils can fix at least some ammonium and that the Water Meadows soil can fix considerable quantities. Nommik (11) made a comprehensive survey of the ammonium fixing capacity of Swedish soils. He found that the soil possessing the maximum fixing capacity was able to fix 2.18 milli-equivalents under experimental conditions similar to those which enabled the Water Meadows soil to fix 1.14 milli-equivalents. Fixation is associated with the clay minerals (2). Since the Swedish soil contained 50 per cent and the Water Meadows soil only 25 per cent of clay, both clay fractions possessed about the same fixing capacity. The fact that some British surface soils, which would appear to be suitable for vegetable growing, can fix ammonium has many implications. For example, it means that consideration should be given to their ammonium fixing capacity in interpreting nitrogen fertiliser experiments.

FLOWERING OF RED BEET PLANTS (S. P. Spragg)

Previous results (12) suggested that one effect of lowered temperatures (4°C.) on the metabolism of the red beet root was to inhibit glycolysis. This inhibition could have resulted from the higher oxygen concentration in the root and from changes in the equilibrium concentrations of certain metabolites.

The beet root at normal temperatures (15°C.) is probably dependent on anaerobic respiration for supplying energy. Thus, subjecting the root to lowered temperatures (4°C.) can cause first an increase in the gaseous content of the tissues, and secondly, a shift in the equilibrium concentrations of many metabolic intermediaries. Measurements of the gaseous composition of beet root sap have confirmed that the carbon

dioxide and oxygen contents of the sap increased at the lower temperature. When the cold treated roots were replaced in a higher temperature (15°C.), the carbon dioxide content decreased more rapidly than the oxygen content. These changes support the hypothesis that one effect of lowered temperatures on the metabolism of red beet roots is the replacement of anaerobic respiration by an aerobic process.

A study of the effects of temperature changes on the concentrations of intermediary metabolites, especially the phosphorylated esters, has been delayed until suitable analytical techniques have been worked out. The use of ion exchange resins as a means of separation of these compounds seems feasible, although this method necessitates the removal of the pigment betanin from the root extracts before separation of the various phosphate fractions. It has so far proved impossible to remove the pigment completely from the root extracts without also removing some of the phosphates. This analytical difficulty suggests that other plant material may have to be used for the study of the effects of cold treatment on the concentration of phosphorylated compounds in plants.

The relationship between colour and quality of beet roots made it desirable to study the changes of the pigments in the roots occurring during the life cycle and winter storage of the roots. The results of this study were reported to the Plant Phenolics Group of The Society for Chemistry and Industry at the Easter symposium (13). They showed that during storage at about 4°C. there was a decrease in the amount of the red pigment (betanin) in the roots, the decrease being greatest in young roots. There was little change, however, in the quantity of the yellow pigment in the roots. These changes in the pigments were very similar to those which occurred in flowering red beet plants during the period of elongation of the flower stalk.

GERMINATION OF SEEDS (S. P. Spragg and P. M. Lievesley)

The study of the chemical changes taking place in germinating seeds, which was previously confined to the pea seed, has been extended to the onion seed during the year.

The changes in the redox states of glutathione during germination of the pea seed suggested that similar changes might occur between the oxidised and reduced states of the sulphydryl groups of the proteins. Chemical analyses have shown that such changes do take place but, owing to decreases in the *total* sulphydryl concentration on the proteins, the interpretation of the results is difficult. However, experiments with selective enzyme inhibitors have suggested that a proportion of the total sulphydryl groups of the cotyledon proteins is in a state of dynamic equilibrium. The maintenance of this state appears to be essential for normal germination.

The results of analyses made on onion seeds of differing ages and viabilities have suggested that death of the seed is accompanied by an increase in the proportion of disulphide to sulphydryl groups on the proteins. A supply of freshly harvested seed was obtained in September 1959 and this is being used to study these changes in ageing seeds.

The study of the chemical reactions occurring during mitosis was continued. The chemical 3-amino-1:2:4-triazole was found to stop division but in contrast with other mitotic inhibitors it did not produce cells which were visibly distorted or abnormal. 3-amino-1:2:4-triazole forms a complex with iron and this reaction is thought to explain its inhibitory action on mitosis.

Iron has been shown by many workers to be essential for mitotic division, but the fundamental role of the iron in this step is uncertain. The possibility that it is required for haem formation cannot be completely excluded, but in view of the relatively small inhibition of most of the haem enzymes by 3-amino-1:2:4-triazole, it seems unlikely that this is the only factor preventing division. It is possible that iron may play a part in providing sites for protein formation in a cell which eventually divides. The inhibitory mechanism of 3-amino-1:2:4-triazole on division would then be essentially

one of inhibition of protein increase in the mother cell. This structural role of iron may be shared by the other metals capable of forming complexes with proteins and with nucleic acids.

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PLANT PHYSIOLOGY REPORT

By E. J. WINTER

In addition to the work reported below, investigations have been continued on environmental effects on onion seed, and tests of a late-flowering strain of watercress are in progress. Further work with gibberellic acid has also confirmed that it had no effect on the flowering of early summer cauliflower.

COMPETITION STUDIES (J. K. A. Bleasdale)

Studies in the field have been continued on the effects of the spatial arrangement of plants on crop yield and the ability of the crop to compete with weeds. In 1959, onions were sown at six rates (3.8, 5.7, 7.6, 11.4, 15.2 and 22.8 lb. per acre) and four row spacings (9, 13½, 18 inch and pairs of rows 4½ inches apart with 13½ inches between the pairs) which were inter-row cultivated shortly after crop emergence. Each plot was subsequently split; half was hand-weeded in the rows as soon as was practicable (26th May) and the other half was similarly weeded 13 days later. The plots were then kept free of weeds and the onions were harvested in late September. The yields obtained were comparatively poor, the early weeded plots having a mean yield equivalent to 5.6 tons per acre as compared with 16.4 tons in 1957 and 16.5 tons in 1958 for the same variety on similar soil. Delaying the first weeding reduced the stand by 17 per cent, and the yield by 44 per cent. The latter reduction was abnormally large in view of the fact that there were only 2.5 weeds per foot of crop row at weeding time. The dry weather, therefore, not only reduced the general yield level but apparently also increased the adverse effect of delayed weeding on yield, even although there were only 2.5 weeds per foot at weeding time. In a normal season, delaying weeding for two weeks reduced the yield by about 10-20 per cent (5). The sowing rate and row spacing treatments did not yield satisfactory data because of the patchy plant establishment and poor growth, both of which could be attributed to the drought conditions which prevailed during the summer.

A detailed growth analysis has been made of red beet in a randomised block experiment with four replicates of four row spacings (12, 18, 24 inch and pairs of rows six inches apart with 18 inches between the pairs) each at the same plant density of approximately 4.5 plants per square foot. In mid-August the roots produced by plants grown in the rows 12 inches apart were approximately 50 per cent heavier than those in the 24-inch rows. At the final harvest in November, however, there were no significant differences between the yields of roots from any of the four row spacings. This result suggests that final yield was controlled by some limiting factor other than spatial arrangement and it is thought that shortage of nitrogen and/or water may have limited the growth in the latter part of the season.

An experiment on the spatial arrangement of carrots confirmed the results obtained in 1957 and 1958. Spacing the rows 12 inches apart increased the marketable yield of roots by 25 per cent as compared with the 24-inch spacing. Rows spaced 18 inches apart, and pairs of rows six inches apart with 18 inches between the pairs gave intermediate yields. The plant was similar at all row spacings and was approximately 8.4 plants per square foot. Over the three years, 12-inch rows yielded at a mean rate of 13.4 tons of marketable roots per acre, whereas 24-inch rows with similar plant densities yielded only 10.9 tons per acre. The results of this series of experiments, which will be published in detail elsewhere, clearly indicate the superiority of close row spacing for carrots.

GROWTH STUDIES (R. B. Austin)

Carrots

A growth analysis was carried out in 1959 on the carrot crop, variety Clucas' New Model, on 16 plots of the Chemistry Section's NPK-FYM factorial experiment (6) using the same sampling procedure as in 1957 and 1958 (2, 3). The only manurial treatment which had a significant effect on growth was the application of 20 tons per acre of farmyard manure, and this treatment increased the yield of roots at harvest in November from the equivalent of 14.7 tons (no-FYM plots) to 19.7 tons per acre. To compare the growth of plants on plots which had received FYM with that of plants on no-FYM plots, net assimilation rates and relative growth rates were calculated, and growth curves constructed by plotting the fresh and dry weights of roots and leaves against various 'time scales'.

For the first five weeks of crop growth the dry weight of the leaves increased exponentially with time. During this period the relative leaf growth rates and net assimilation rates of plants on the + FYM plots were 22 and 30 per cent respectively, greater than those of plants from the no-FYM plots. At the end of this period the dry weight of leaves per plant on the + FYM plots was 3.0 times as great as that on the no-FYM plots.

From the age of five weeks until harvest in November, the average relative leaf growth rate was greater in plants from the no-FYM than from the + FYM plots but the average net assimilation rates did not differ. Relative leaf growth rate and net assimilation rate declined linearly with increase in the quantity $T^{\frac{1}{2}}$, where T was the dry weight of the leaves. Absolute growth rate, however, was always greater in plants from the + FYM than from the no-FYM plots because of the greater weight of the leaves on the + FYM plants.

Information on the effect of weather conditions on crop growth was obtained by comparing the rates of increase in dry weight of leaves and roots at a given plant age in different years. In 1959, leaves grew faster than in 1958 during the exponential period of growth, but thereafter the growth rate in 1959 was slower than in 1958. The edible roots grew faster in 1959 than in 1958 throughout the life of the crop. The effects of weather on growth during individual years was determined by comparing the slopes of the growth curves and the values of the constant k as determined by fitting the data to the logistic equation of growth (3):—

$$W = \frac{a}{1 + be^{-kt}}$$

Red beet

A growth analysis similar to that described for carrots was carried out in 1959 on the red beet crop, variety Detroit Globe Red, on 16 of the plots of the Chemistry Section's NPK-FYM factorial experiment. As with the carrots, only the application of FYM had a significant effect on growth and yield at harvest. The application of 20 tons per acre of FYM increased the yield at harvest in October from the equivalent of 7.9 tons (no-FYM plots) to 14.4 tons per acre.

The dry weight of the leaves increased exponentially with time for the first five weeks of crop growth and during this period the relative leaf growth rate and net assimilation rate of plants on the + FYM plots were 14 per cent greater than those of plants on the no-FYM plots. From the age of five weeks until harvest the average net assimilation rate of plants on the + FYM plots was 10 per cent less than on the no-FYM plots and the average relative leaf growth rate was 23 per cent less.

An attempt was made to determine whether the differences in the net assimilation rates between plants grown on + FYM and on no-FYM plots were the result of inherent differences in the rate of assimilation or respiration of the leaves. Discs of leaf tissue were removed from plants on the plots, floated on tap water and exposed for six hours under constant conditions of temperature and illumination. From the

relative changes in dry weight of the tissue exposed to light or kept in the dark, assimilation and respiration rates were estimated. The results indicated that the lower net assimilation rates of the leaves of plants on the +FYM plots after the exponential period of growth was the result of a greater increase in leaf respiration rate on the +FYM than on the no-FYM plots.

ONION INVESTIGATIONS (R. B. Austin)

Pickling onions. A randomised block variety trial was carried out at Wellesbourne in 1959. The varieties used included four pickling onion varieties, Thoday's New Brown Pickling, Thoday's French Pickling, Thoday's Rijnsburger Pickling and Thoday's German Pickling, and two ware varieties previously shown to yield crops of bulbs of suitable shape and texture for pickling, Giant Zittau and Rijnsburger. The plots were dressed with 10 cwt. per acre of inorganic fertiliser containing 12 per cent nitrogen, 9 per cent phosphate (P_2O_5) and 9 per cent potash (K_2O), and the seed was sown on 24th March at the rate of 30 lb. per acre in rows 9 inches apart. After harvest in September the bulbs were riddled into four size grades and No. 1 grade (1 inch to just under $1\frac{3}{8}$ inches in diameter) was retained for quality assessment.

Total yields and yields of marketable pickling onions were very much lower than in 1957 and 1958 and this was attributed to the dry season in 1959. The No. 1 grade onions were assessed for shape and texture in the raw and the pickled state by representatives of the pickling trade, by arrangement with the British Food Manufacturing Industries Research Association. In the raw state all the varieties tested were of acceptable shape and texture for pickling. Considering the results of variety trials carried out in 1957, 1958 (1, 4) and 1959, the pickling variety New Brown Pickling (Thoday's) and the ware variety Giant Zittau consistently yielded crops containing a higher proportion of onions in the pickling grades, acceptable in shape and texture for pickling, than the other varieties tested. The ware variety Rijnsburger gave heavy yields of pickling-size bulbs of the desired texture but, in general, the bulbs were too elongated to be of the best pickling quality.

PROTECTED CROPPING

Black polythene film as a soil mulch (R. B. Austin)

Lettuce plants, variety Trocadero Green, were raised under glass and on 3rd April 1959 were transplanted through holes in 0.0015 inch thick black polythene film used as a soil mulch, and in unmulched control plots. Cutting of marketable lettuce was completed by 1st June. On the average, lettuces matured two days earlier and their mean fresh weight was 6 per cent greater on the mulched than on the unmulched plots, and these differences were significant. A greater proportion of plants also reached a marketable condition on the mulched than on the control plots. Measurements of air and soil temperatures and of available soil water were made during growth. The amount of available soil water was significantly greater in the mulched plots than in the control plots (temperature differences were not significant) and probably was the main cause of the above-mentioned differences between the crops at harvest.

Glazing materials (J. K. A. Bleasdale)

During the winter 1958-59 the growth of lettuce was compared under standard Dutch lights 'glazed' with translucent polythene, clear PVC, clear cellulose acetate and with glass. Each plot was a small frame covered with two standard Dutch lights. A randomised block layout with five replicates was used, with two additional frames in each block — one covered with glass and one with cellulose acetate, making a total of 30 frames. The cellulose acetate was found to contain a phytotoxic plasticiser and the manufacturers have since fabricated non-phytotoxic sheets which will be used in future experiments.

Half the lettuce plants in each frame were cut on 21st April and the remainder were cut on 29th April. Similar numbers of plants survived till harvest in all treatments but the plants under glass were always more mature than those under the plastics. For instance, at the second harvest 39 per cent of the plants under glass were marketable, but under PVC and polythene, only 22 and 11 per cent respectively were marketable. The mean weights of the marketable plants were 187 gm., 190 gm., and 102 gm., respectively.

Temperature and light measurements made from time to time during the experiment indicated that the maximum temperatures and the amount of light transmitted were always lower under the plastics than under glass. It is thought that these differences in the environments adequately account for the observed effects on growth.

Acknowledgments

Thanks are due to the British Food Manufacturing Industries Research Association, Leatherhead, for assessing the pickling quality of the onions. We also wish to acknowledge the assistance of our colleague, Mr. J. A. Nelder, and of the Statistics Department of Rothamsted Experimental Station in the mathematical treatment of our data.

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IRRIGATION REPORT

By E. J. WINTER

The dry weather during the growing season of 1959 was well suited to carrying out irrigation experiments. At Wellesbourne during the five months May to September the potential evaporation of water from an open water surface or from wet soil totalled about 19 inches, whereas rainfall during this period was only 3.45 inches (see page 54).

In addition to the work reported below, studies have been continued on the growth of the cauliflower plant, on biological effects of varying the droplet size of irrigation water, on the effects of wind on plant growth, on the use of weather factors to provide 'time scales' for growth analysis, and on various aspects of the different methods of determining soil moisture characteristics.

Dr. P. J. M. Sale joined the Section in August 1959 and has begun work on the effects of additives, including fertilisers, to irrigation water. He is also investigating the extent to which the temperature of irrigation water affects crop growth.

IRRIGATION OF CAULIFLOWERS (P. J. Salter)

In the propagating frame

Previous experiments (3, 4) showed that dry soil conditions during the propagating stage of autumn-sown, early summer cauliflower plants of the variety Finney's 110, caused the plants to produce smaller, earlier curds than plants kept moist during the propagating stage. The experiment was repeated during the season 1958-59 using two varieties, Finney's 110 and Remme. The young plants growing in three-inch pots in frames were subjected either to a wet or dry soil-moisture treatment from 16th October 1958 until 2nd March 1959 when they were planted in the field. Under the wet treatment the plants were watered every other day; with the dry treatment the soil was allowed to dry almost to the wilting point before being watered. After planting in the field, half of each batch of plants was irrigated whenever the available water in the root zone had been depleted by 25 per cent, sufficient water then being given to restore the soil to field capacity. The other half of each batch of plants received no water other than rainfall.

With both varieties the dry treatment in the propagating stage decreased the leaf number, head weight and curd size at harvest, and slightly hastened maturity as compared with the wet treatment. Plants irrigated in the field produced greater head weights and larger curds than plants which received rain only.

The results with variety Finney's 110 supported those of the previous two years. The variety Remme, on the other hand, responded to the treatments in the same manner as Finney's 110 in 1958-59, but showed no difference in response to the treatments in 1957-58 (4). A paper on these experiments is in the Press.

In the field

The response of early summer cauliflower plants of the variety Finney's 110 to high or low soil moisture conditions at different stages of growth in the field was determined as far as weather conditions would allow. Eight different irrigation treatments were applied and the number of irrigations per treatment varied from one to ten over the twelve-week period from planting until harvesting.

Ample rainfall for the first six weeks after planting resulted in a soil moisture deficit of less than 0.5 inch and consequently irrigation during this time was not beneficial. However, as the soil moisture deficit increased during May and June, the later irrigation was carried out, the greater was its effect on yield. A single irrigation of one inch of water, applied just before cutting started, increased the mean head

weight by 25 per cent and the mean curd diameter by 0.6 inch. This treatment could be regarded, therefore, as the most economically sound, because, although a slightly larger curd was obtained when the soil moisture deficit was not allowed to exceed 0.5 inch at any time, six irrigations each of 0.5 inch of water were needed to achieve this result.

The results from this and previous experiments (5) show that, in order to give maximum yield, the early summer cauliflower requires a plentiful supply of water from rainfall or irrigation throughout its life. In a year of average rainfall, however, provided that there is enough moisture in the soil to establish the plants, only two or three irrigations between planting and harvest time should be sufficient to ensure a satisfactory, though not maximal, yield under reasonably good growing conditions.

Plant spacing and irrigation

Early summer cauliflower plants, variety All the Year Round, were grown at four spacings (34 by 34, 24 by 24, 17 by 17, and 12 by 12 inches), and were irrigated whenever 25 per cent of the available water had been depleted from the soil. The control plots received rain only. The results indicated that irrigation increased head weight by about 25 per cent at each of the plant spacings. The different spacing treatments markedly affected both head weight and curd diameter, e.g., the mean curd diameter of plants at 34 by 34 inch spacing was 5.9 inches, and at 12 by 12 was 2.7 inches.

IRRIGATION OF PEAS (P. J. Salter)

Seeds of the pea variety Dark-Skinned Perfection were sown in soil at field capacity on 25th May 1959, and rain was prevented from interfering with the four different irrigation treatments by means of movable glass shelters (9). The results indicated that, under the conditions of this experiment, an increase in the amount of water applied between sowing and flowering time increased haulm weight but did not increase the yield of shelled peas. It must be pointed out, however, that the soil was at field capacity at sowing time; had this not been so, a different result might have been obtained. Irrespective of watering treatment prior to flowering, 0.5 inch of water applied when the pods began to swell increased the yield of shelled peas by 15 per cent, but slightly delayed maturity.

STUDIES ON ROOT SYSTEMS (D. H. Drew)

Investigations into the form and function of vegetable root systems have been started in order to provide a better understanding of the interaction of irrigation and fertiliser application.

Morphological study in the field

The root distribution of lettuce variety Borough Wonder, grown under different watering treatments, was studied by counting the number of roots visible in each square inch of washed soil profile on four vertical sections — one at the centre of the plant, one near the lateral limit of root spread, and two intermediate between these. Fourteen mature root systems and twenty-four at earlier stages of growth were excavated and examined. The results showed that the lettuce root system had a characteristic form, which was only slightly modified by varying the watering treatment.

Differences in root distribution appeared to be caused more by heterogeneity of the soil than by differences in watering treatment. Profuse branching of roots occurred in patches of farmyard manure, whereas branching was sparse in compact regions of soil, and profuse just above them. Roots penetrated deeply down worm-holes and natural cleavage planes in the soil.

These observations agree in the main with those made on lettuce root systems by Weaver and Bruner (8).

Physiological study in the glasshouse

Initial experiments were made to compare the absorbing powers of the upper and lower regions of lettuce root systems. The plants, variety Cheshunt 5B, were grown in pairs of tapering, waxed, cardboard cartons — a bottomless carton standing upon a complete one so that the upper and the lower regions of the root systems could be treated separately with water or with nutrient solution.

In the first experiment, the rooting medium was a peatless compost equivalent in nutrient content to J.I.P. 1, and comparatively hard borehole water was used for watering. Applying nutrient solution always to the upper part of the root system and water as needed always to the lower part, or vice versa, gave no difference in effect on yield of fresh or dry weights of heads or roots. It was, therefore, concluded that either the upper or the lower part of the lettuce root system was capable of absorbing separately the water or the nutrients needed by the plant.

Transposing the treatments part-way through the life of the plants also produced no differences in effect on yield, thus indicating that the different parts of the root system had not become physiologically adapted to the absorption either of nutrient or of water. Furthermore, no morphological evidence of such adaptation was found.

In the second experiment, sand was the rooting medium and rain water was used instead of borehole water. The same total quantity of nutrients was applied, either to the upper part of the root system, or to the lower part, or equally to both parts. Irrespective of nutrient treatment, the sand in both parts was kept at the same moisture content. Thus with some plants, some of their roots were subjected to high osmotic pressure which would be expected to impede the uptake of water and facilitate the uptake of nutrients, while the remainder of the roots were subjected to low osmotic pressure which would favour the uptake of water. On the other hand, those plants which received nutrient in both parts of their root systems were subjected to an intermediate osmotic pressure.

These treatments caused no differences in fresh or dry weight of heads or total roots. This suggests, therefore, that a part only of the root system was by itself capable of absorbing either the full nutrient or the full water requirement of the plant, and that there was no apparent difference between the upper and lower parts of the root system in this respect. Allerton (1) has produced similar evidence for tomatoes. Although the total weights of roots produced was similar in all these treatments, a larger proportion of roots was concentrated in that part of the root system to which the nutrients were applied as compared with that where the water only was given.

IRRIGATION OF A ROTATION OF VEGETABLE CROPS

(F. Lucy C. Blackwall and E. J. Winter)

The long-term experiments on the irrigation of various crops at the Experimental Horticulture Stations of the N.A.A.S. were continued (10). In 1959 the irrigation indicator (6) was used for the first time in a field experiment. At Luddington, early summer cauliflowers were watered whenever one-inch soil moisture deficit had accumulated, about one inch of water being applied at each irrigation. For one set of plots the indicator was used to decide when this deficit had arisen, while for another set the deficit was estimated as in previous years by means of a modification of the Penman method. According to the indicator, the critical deficit arose only twice during the life of the crop, whereas according to the estimate it arose three times. Thus 2.53 inches of water were applied to the indicator-controlled plots, and 4.31 inches were applied to the others. Nevertheless, the yield of marketable heads from both sets of plots was the same, and about 70 per cent more than that from non-irrigated plots. The rainfall during the 12 weeks from planting-out time until harvest was 4.39 inches.

The plants used in this experiment had been subjected to two different watering treatments while being raised in pots in an unheated glasshouse throughout the winter. Those plants which had been watered frequently during this time gave higher yields

when subsequently grown on in the field, than those which had been raised under the normal rather dry conditions. This confirmed previous results obtained at Wellesbourne (3).

At Efford in 1959, the yield of early summer cauliflower which had been irrigated whenever ¾-inch soil moisture deficit had arisen (irrigations totalling 3.21 inches) was 192 per cent higher than that of unwatered plants. Rainfall between planting out and harvest, however, was only 2.02 inches, and the overall yield of the experiment was below average.

Early potatoes at Efford which were irrigated, like the cauliflowers, throughout their life at ¾-inch deficit (total irrigation 4.96 inches), yielded 54 per cent more than unwatered controls. Irrigation of lettuce, as in previous years at Efford, again failed to increase the yield. Some indication of the reason for this result was obtained in another experiment in which the depression in yield caused by irrigating with ordinary spraylines was avoided when the water was applied through special fine jets which reduced the droplet size.

At Rosewarne, there was no significant response to irrigating early potatoes, but this result may have been caused by the lifting of this crop relatively early in its life.

As the experiment at each centre completes one cycle of the crop rotation, the watering treatments are being changed towards irrigating less frequently and with smaller total quantities of water than hitherto. Work at Wellesbourne has shown that moisture-sensitive stages exist during the growth of some vegetables (7), and some of the new treatments are intended to compare the effects of irrigating only at such growth stages, with the effects of maintaining a specified minimum soil moisture deficit throughout the life of the crop.

At Luddington, the results of irrigating peas supported those obtained at Wellesbourne (see page 31). A 37 per cent increase in yield of shelled peas was obtained by irrigating only once after flowering, and a 13 per cent increase by irrigating twice before and once after flowering, as compared with the yield of unwatered plots. There were almost no differences between tenderometer readings obtained with peas grown under each of these treatments.

In a dry season a comparatively small amount of water applied at a suitable time may result in a worthwhile yield increase. For example, at Efford, early potatoes irrigated twice with a total of 1.83 inches of water after the tubers had begun to form, yielded 30 per cent more than the controls. In the same experiment, as mentioned previously, nearly five inches of water were needed to raise the yield by 54 per cent.

FACTORS AFFECTING THE SET OF RUNNER BEAN PODS

(F. Lucy C. Blackwall)

Field and glasshouse investigations were continued in 1959 into possible causes of the frequent failure of runner beans to set a full crop of pods especially during the early part of the season.

Plants of the variety Streamline were subjected to three treatments:— (*a*) control— no irrigation, (*b*) 0.5 inch of water applied whenever the measured evaporation from an open water surface totalled 0.75 inch since the previous watering, and (*c*) 0.25 inch of water applied daily in alternate weeks, thus providing a fluctuating soil moisture content which is one of the conditions often thought to cause poor pod set. All the treatments were started when flowering began.

Freshly-opened flowers were marked and, later it was noted whether these flowers fell off or set pods. Crop yield was increased by both irrigation treatments, (*b*) plots yielding 56 per cent, and (*c*) plots 21 per cent more by weight than control plots. This increase was the result both of a larger number of pods being retained and of the individual pods being heavier. The increase in pod numbers was 35 per cent and 11 per cent for the (*b*) and (*c*) plots respectively.

Syringing the open flowers with water twice daily on warm dry days, again failed to increase the percentage of flowers which gave pods at harvest as compared with non-syringed plants, thus confirming a previous year's finding (2).

It has been suspected that variation in yield of early pods might be associated with differences in fertility level, and some of the blocks of one experiment in 1959 were deliberately sited on a patch of soil which, as a result of previous cropping, would be expected to have a higher level of fertility than the remainder of the experimental area. The mean early yield from these blocks was 278 per cent more than that of the other blocks.

Experiments under glass confirmed that, at seasons of the year when there was little insect activity, hand pollination was necessary in order to set pods on the early flowers of varieties Streamline, Princeps and Kelvedon Marvel. It is evident, therefore, that natural self-pollination of these varieties is incompletely effective.

Acknowledgments

We wish to thank the Directors and staffs of the Experimental Horticulture Stations at Luddington, Efford and Rosewarne for carrying out the experiments on the irrigation of a rotation of vegetable crops. We are grateful also to the Director and staff of the Fruit and Vegetable Canning and Quick-freezing Research Association, Chipping Campden, for making tenderometer and canning tests on peas.

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ENTOMOLOGY REPORT

By D. W. WRIGHT

The work of the Entomology Section during 1958-59 was mostly concerned with projects which had been under investigation for some time. Field and laboratory studies were begun, however, on the carrot-willow aphid, a serious pest of the carrot crop, and investigations to determine the degree of persistence of insecticides in soils, which were started in 1958, have been much extended.

THE BIOLOGY AND NATURAL CONTROL OF THE CABBAGE ROOT FLY

(D. W. Wright, R. D. Hughes, Dorothy D. Salter and Jennifer Worrall)

Egg laying by the cabbage root fly began at Wellesbourne on 21st April, some ten days earlier than in 1958. This early start, combined with an unusually warm summer and autumn, allowed this insect to pass through three full generations in the season.

Population studies showed that, as in 1957 and 1958, the mortality in the egg stage was very high and resulted in a far greater reduction in the numbers of this pest than did the combined mortalities at all other stages. Frequent records of the numbers of eggs and of the numbers of predatory beetles on brassica plots showed that the greatest egg losses occurred when the largest numbers of beetles were trapped.

To determine the importance of the beetle predators in natural control of the cabbage root fly and on the damage caused by this insect, a field experiment was carried out using early cauliflowers. These were transplanted in early April and were attacked during late April and in May by the first generation of the root fly. The most abundant beetle predator in the field over the period was the wingless form of *Bembidion lampros* (Herbst). An attempt was made to obtain different levels of beetle populations within experimental plots by using barriers to restrict beetle movement into and out of the various plots. A barrier of straw placed on the soil around the plots and sprayed at ten-day intervals with a DDT emulsion decreased the numbers of beetles within these plots and allowed greater numbers of eggs to survive than on nearby plots with no barrier (untreated). This resulted in greater numbers of root fly larvae and greater crop damage on the plots surrounded by the straw barrier; the crop yield on these was only 62 per cent of that on the untreated plots. Another type of barrier allowed the beetles to enter the plots but made it difficult for them to leave. On these, greater numbers of beetles occurred and fewer cabbage root fly eggs and larvae survived than on the untreated plots. On the latter, 35 per cent of the plants showed marked symptoms of root fly attack as compared with 22 per cent similarly affected on the catch barrier plots. The crop yield was slightly higher on the latter plots than on the untreated plots. Also included in the experiment were plots of cauliflower which received the standard insecticide treatment for the control of cabbage root fly larvae. The insecticide was applied to the soil around the plant where the eggs were laid. This gave an increase in yield of 79 per cent as compared with the untreated plots.

The results of this experiment confirmed those obtained in 1958 and showed that the beetle predators of the cabbage root fly played a very important part in the natural control of this insect. Where the numbers of predators were decreased, greater numbers of the pest survived and the crop damage was increased. Although the use of insecticides to control the cabbage root fly is economically necessary, it does appear, however, to cause some mortality of the natural predators. Such losses can be reduced to a minimum by restricting the application of insecticides, wherever possible, to the soil immediately around the plant.

THE CONTROL OF CARROT FLY (D. W. Wright)

The prolonged drought during the summer and autumn of 1959 affected the breeding of the carrot fly adversely and the damage caused by this pest was generally much less than in previous years. At Wellesbourne, the infestations on all experiments were too low to enable differences in the performances of insecticidal treatments to be accurately assessed. On fen soil at Chatteris, however, although the attack of this pest on carrots and celery was below normal, as many as 60 per cent of roots were infested on untreated plots. Dieldrin at 1½ lb. per acre worked into the soil to a depth of four inches before sowing gave an almost complete control of carrot fly on carrots, whilst the same amount applied a year previously gave an 80 per cent control of the pest on carrots grown in the soil in 1959. Dieldrin shows great persistence in soils; a fen soil treated with 2 lb. per acre of this insecticide in 1956 and since ploughed, cultivated and cropped each year with carrots, carried a crop in 1959 with only 7.5 per cent of attacked roots as compared with 32·5 per cent infested on the untreated plots. Residue determinations in soil samples obtained from these plots in November 1959 indicated that about 1 lb. of insecticide per acre was still present in the soil some three years and seven months after it was applied. This suggests that if such soils are to be retreated with dieldrin, then the amount required, after a period of four years, would be not more than half of that originally applied.

Diazinon, a phosphorus containing insecticide of low mammalian toxicity, has also been used in field experiments for the control of carrot fly. In 1958, when incorporated into the soil at 2 lb. per acre before sowing, it gave an excellent control of both first and second generations of the pest at both Wellesbourne and Chatteris. In 1959, however, it was effective only against the first generation and soil treatments carried out in April gave no reduction in the damage caused by the second generation attacking the crop in the autumn. Diazinon appeared to be much less persistent in soils than dieldrin and the warm, dry soil conditions prevailing throughout much of the 1959 season may well have brought about a more rapid disappearance than occurred in the cool and moist conditions of the previous year.

Heptachlor in the soil, at dosage rates comparable to those used with dieldrin, was also found to be very effective against carrot fly.

Tasting tests on carrots grown in soil treated with diazinon or heptachlor showed that, when used at the above mentioned rates, neither insecticide had any adverse effect on crop flavour.

LETTUCE ROOT APHID (J. A. Dunn)

In 1959 there were very few lettuce root aphid galls on poplar and as a result the number of winged aphids at migration time was extremely small. Weather during the migration period, however, was unusually fine and, on reaching lettuce, the aphid was able to establish its subterranean colonies rapidly. Hot, sunny weather continued throughout the summer and lettuce root aphid built up to pest proportions on a scale comparable with that of 1955. With a high potential attack by root aphid, the effectiveness of certain insecticide treatments against this pest was clearly demonstrated in experimental plots at Wellesbourne. Endrin seed dressings followed by an endrin band spray applied to the lettuce just after singling gave, as in previous years, 90 per cent control of aphid numbers. This treatment proved more successful than those involving two seedling sprays of diazinon. The most outstanding levels of control (from 99 to 100 per cent) were obtained, however, with soil treatments of endrin, thimet or diazinon. These insecticides were applied to the soil, and rotavated into the top three inches before sowing the lettuce. Rates equivalent to 2 and 4 lb. per acre of actual insecticide were used.

The problem of spray residue on lettuce foliage can be of considerable importance when a material like endrin is used, but it does not arise with a pre-sowing soil application of the insecticide. This method of treatment against root aphid, therefore, is to be recommended. When applied to the soil, endrin, thimet and diazinon gave

insecticidally similar results but the high mammalian toxicity of thimet, together with its long-lasting systemic property, make it desirable to use either endrin or diazinon. Of these two insecticides, diazinon is preferable, since it is safer to handle and disappears from the soil over a shorter period of time.

CARROT-WILLOW APHID (J. A. Dunn)

A study of the biology and control of the carrot-willow aphid, *Cavariella aegopodii* Scop., was begun in 1959. This aphid attacks early carrots causing twisting and malformation of the foliage, accompanied by stunting and, in severe cases, by the death of the plant. Yellow or red leaf discoloration can also be symptomatic of the attack.

The aphid overwinters in the egg stage on willow, *Salix fragilis* and *S. alba* being common hosts. The eggs hatch in phase with bud-break of the winter host and as willow characteristically breaks bud very early in spring, carrot-willow aphid develops and its winged migrant forms appear much earlier than happens with many other species of aphid. Observations in 1959 showed that the aphid began migrating to carrots during the second week in May. The migration continued throughout May and June, and carrots sown on 3rd April, which were not out of the cotyledon stage when the first aphids began alighting on them, were subjected to an intense and prolonged attack. Having alighted on carrots, the winged aphids produced small, green-coloured young which settled along the mid-ribs of the leaves and leaflets. Here they fed, matured and in turn reproduced. The numbers increased rapidly, especially as they were supplemented by the reproduction of repeated influxes of winged migrants from willow. At Wellesbourne peak numbers of aphids were built up on carrots by the third week of June when more than 400 aphids per plant were recorded. The carrot foliage supporting this population became shiny and sticky with honey dew and the soil below was coated with cast aphid skins giving it the appearance of having been sprinkled with cigarette ash. The aphid left the carrots in July to fly to wild Umbelliferae or to return to willow.

Several insecticides were used against this aphid in a field experiment. A seed dressing of thimet 44D* was tried, after germination tests done in the glasshouse had shown that no phytotoxicity resulted when thimet was used at 10 per cent by weight of dressing to seed. In the field, however, the germination of carrot seed dressed in this manner was almost completely prevented. Two spray applications of endrin proved to be more effective than two of diazinon, and gave a control of the aphid which resulted in more than a 50 per cent increase in crop yield compared with untreated plots. A single spray of metasystox, applied when the crop had reached the third true-leaf stage, was slightly more effective than the endrin treatment. The most successful treatment was a soil application of 8 per cent granular thimet at the equivalent rate of 4 lb. actual insecticide per acre. The thimet was broadcast and rotavated into the top three inches of soil before the carrots were sown. Although a complete control of the aphid was not obtained with thimet soil treatment, the reduction in aphid numbers was such that the yield of carrots was increased by 70 per cent above that on untreated plots. Until the residue levels and persistence of thimet in carrot tissue have been evaluated, however, a soil treatment using 4 lb. of this material per acre cannot be recommended. Nevertheless, it has served to show how seriously this pest can affect the crop yield.

CONTROL OF CABBAGE APHID ON BRUSSELS SPROUTS AND KALE (T. H. Coaker)

In the late summer of 1959 there was a severe attack of cabbage aphid (*Brevicoryne brassicae* L.) on many brassica crops. Following reports from other workers that the commonly used systemic insecticides were not as effective in controlling the pest as in

*Carbon powder containing 44 per cent actual thimet (diethyl ethylthiomethyl dithiophosphate) and 2 per cent methyl cellulose.

previous years, two trials were laid down at Wellesbourne to observe and compare the action of several insecticides. One trial was on Brussels sprouts, the other was on kale.

The insecticides were applied, together with a wetting agent, as high volume sprays (approx. 100 gallons per acre) when the infestation was well established. Of those applied to Brussels sprouts, metasystox (0.04 per cent active ingredient) and PP.175* (0.008 per cent a.i.) appeared to be the most effective. Similar results were obtained on kale, but in this trial rogor (0.04 per cent a.i.) was also included and gave results equal to metasystox and PP.175. Fluoracetamide sprays applied at two concentrations (0.015 and 0.02 per cent a.i.) were less effective, exhibiting a short-lived contact action only. None of these insecticides gave more than a partial control of the pest and the degrees of control achieved were largely due to the contact effects of the sprays. Systemic action, even with the most effective materials, was poor and limited to a translaminar effect only. As a result, aphids within sprouts or in similar protected positions were unaffected. Their numbers increased rapidly so that on all treatments the population quickly recovered and within 20 days of spraying they had reached levels equal to, or exceeding, those occurring on the plants before treatment.

The low level of control obtained was probably due to the warm dry conditions during the growth of the crops which limited translocation and increased the waxy covering on the leaves, thereby greatly reducing the systemic action of the insecticides listed.

BIOASSAY OF INSECTICIDE RESIDUES IN SOILS

(G. A. Wheatley and J. A. Hardman)

Work was continued on the development of a sensitive bioassay technique for measuring residues of certain insecticides in soil. A satisfactory method has been devised for assaying dieldrin in soil at concentrations of from 0.05-5 p.p.m. approximately, the minimum amount being equivalent to about 0.1 lb. per acre distributed to a depth of 8-10 inches. Since a direct method of assay was insufficiently sensitive for our purposes (1), it has been necessary to resort to an extraction technique whereby the insecticide is removed from the soil by means of a suitable solvent such as acetone. Extracts are also prepared of soil to which known amounts of an insecticide have been added immediately before extraction in order to provide standards for the assay. The extract is applied to cotton dental rolls (approx. 1 cm. diam. $\times$4 cm. long) and adults of the vinegar fly, *Drosophila melanogaster* Meig., are confined with the treated rolls which have also received a little of a syrup solution to attract the flies and to provide nutriment for them. By comparing the response of the flies to the 'unknown' extracts with the response to the standards, the amount of insecticide in the samples can be estimated to within about 10 per cent.

To obtain maximum sensitivity and to enable a wide range of doses to be assayed, it is necessary to record on a number of occasions during a period of 3-4 days the effect on the test insects, and the observations must be arranged to follow a logarithmic time sequence. An apparatus has been designed and constructed to enable the responses of the flies to be recorded automatically at the desired times thus making the method practicable for routine use.

The interpretation of the results of assays depends, among other things, on the reliability of the method used and this is governed by the errors involved in obtaining and handling the samples as well as in the actual assay in the laboratory. Preliminary studies of the errors associated with the technique have demonstrated clearly the difficulty of obtaining good representative soil samples from the field because of the imperfect distribution of the insecticide in the soil. The amount of dieldrin in different soil cores from the same plot has been found to vary by as much as 9 : 1 on a plot which had been treated several years previously and subsequently ploughed and

*A triazinyl phosphate.

cultivated each year so that the insecticide could be expected to be distributed more evenly than on freshly-treated land. Unless a very large number of cores per sample (100 or more) are taken it seems unlikely that sampling error can be reduced much below 8-10 per cent and this will probably be the limiting factor determining the accuracy of the assays.

The vertical distribution of dieldrin in the soil has been studied on two plots which had been treated at different times and subsequently cultivated in different ways. The first plot had been treated in April 1959 and the insecticide had been mixed into the soil by double rotary cultivation to a depth of 10 cm. When soil from different depths was assayed in September 1959 no insecticide was found below 7 cm. and it was clear that rotary cultivation had failed to carry down the material to the full depth of cultivation. The second plot examined had been treated in March 1956 but, in addition to two initial rotary cultivations, it had been ploughed three times to approximately 20 cm. In this case, 98 per cent of the dieldrin recovered was found in the cultivated layer of the soil so that any movement downwards was slight.

The bioassay technique has also been used to check on the possible contamination of land about to be used for experiments on soil insecticides. In two cases, small residues have been detected which were thought to have resulted from the use of seed treatments on crops grown in recent years and this has stressed the need for pre-treatment assays before laying down experiments involving the use of insecticides in soil. The widespread use of insecticides and the long times for which residues persist in the soil suggest that it will become increasingly difficult to find truly insecticide-free soil for experiments of this type.

Acknowledgments

We are much indebted to Mr. A. S. Rickwood, M.B.E., Chatteris, for providing many facilities for experiments on the control of carrot fly; to the Department of the Government Chemist for examining carrot samples for insecticide residues, and to the various Chemical Companies who have provided insecticides for experiments. We wish to thank also the members of the research staff at Wellesbourne who served on the tasting panel.

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PLANT PATHOLOGY REPORT

By W. G. KEYWORTH

SILVERING DISEASE OF RED BEET (W. G. Keyworth and J. Sheila Howell)

Experiments were made on the spread of this disease during the autumn and winter of 1958-59. Probably because of the wet weather the spread was considerable, numerous infected plants being found in plots located up to 50 yards from the nearest source of infection. There were also severe outbreaks on some commercial holdings. 20 per cent disease was seen in fields in which the plants had been grown from seed that had been treated with mercurial dusts, although disease incidence was much lower (1-4 per cent) among plants grown from seed treated with streptomycin. Most growers and seedsmen have used the latter compound for seed treatment for the 1960 crop.

During October and November 1958 observations on experimental plots containing 1-4 per cent of silvered plants showed that many of the apparently healthy plants bore the pathogen on or in their leaves, especially around the edges. Such plants showed systemic symptoms in March-April 1959 and it is considered that the leaf edges are an important entry point for the pathogen.

CROOK ROOT OF WATERCRESS (J. A. Tomlinson and Bridget R. Smith)

Commercial trials on the use of zinc frit for the control of the disease (6) have been made by growers in many localities. When applied over the whole of the watercress bed at the rate of 1 lb. per square yard zinc frit controlled the disease but caused yellowing of the plants in some beds. Studies by the Chemistry Section have shown that the chlorosis was caused by an interference in the iron metabolism of the plant. In other trials, however, in which zinc frit was applied to the upper half or third of the beds at $\frac{1}{2}$ lb. per square yard the disease was also controlled and no chlorosis occurred. The treatment thus controlled the disease in areas of the bed receiving water from the fritted area. This is presumably because having flowed over zinc frit the water contained enough zinc to kill zoospores of the fungus in the water for some (at present) unknown distance.

MOSAIC DISEASE OF WATERCRESS (J. A. Tomlinson and Bridget R. Smith)

This disease has been greatly reduced in many farms by growing green watercress from seed (7). On some farms, however, healthy stocks had been planted near old infected stocks of watercress and, as a result, the healthy stocks rapidly became infected.

DIDYMELLA STEM ROT OF OUTDOOR TOMATOES (R. B. Maude)

In 1958 the F_1 progeny of a cross between *Lycopersicon hirsutum* and *L. esculentum* variety Harbinger were inoculated in the field and found resistant to stem and soil infection with *Didymella*. In 1959 more F_1 plants and the first backcrosses (to *L. esculentum*) were provided by the Plant Breeding Section, and were tested for resistance under glasshouse conditions. In these trials seedling inoculation methods were used which enabled large numbers of plants to be tested. Segregation for resistance occurred in the backcross generation. The breeding and resistance-testing programme is being continued.

PARSNIP CANKER (A. G. Channon)

Further investigation of the effects of different sowing dates on the development of the disease has confirmed the observations made in 1957-58 that roots from a sowing in June developed less canker than those from a sowing in March (4). May-sown roots developed the disease to a degree intermediate between those of the earlier and later sowing dates. The principle difference was in the size of the lesions on the roots, rather than the numbers of roots infected. This was observed both in October and January. The effect of root size on canker development was studied in the same experiment by singling some plots to 3 inches and others to 6-inch intervals, row spacing being 15 inches. The small roots from the close spacing showed a lower percentage infection and bore smaller lesions than the larger roots. Most of the canker in this experiment was of the black type.

The highest total yield of roots was recorded on the March-sown plots singled to 6-inch spacing. The amounts of canker and bolting were so high, however, that the marketable yield was less than on the June-sown roots singled to a similar distance.

In a study of the effects of adding parsnip root material to the soil it was found that canker developed to a similar extent in plots which had received either infected or uninfected root tissue. The amount of canker was much greater than on plots receiving no root tissue. This experiment is being continued in 1959.

Field tests of a number of fungicides applied to the soil showed that marked reductions in canker could be obtained with either captan or PCNB at a concentration of 0.8 per cent applied as a single drench along the rows at a rate of $\frac{1}{4}$ pint per square yard in July.

Selection and testing of resistant lines of parsnips in the field has been continued, and three promising selections were subjected to tasting tests by the Research Station tasting panel. All three lines, through differing slightly in flavour from the Offenham variety used as a standard, were found to be of satisfactory palatability.

CLUBROOT OF BRASSICAS (A. G. Channon)

The investigation of the effects of aldrin on clubroot of Primo cabbage was continued at the Luddington E.H.S. with the object of testing the value of pre-planting dip treatments. The concentrations of aldrin ranged from 0.04 per cent to 0.32 per cent and in some treatments a sticker was incorporated in the dipping suspension to increase the amount of compound adhering to the roots. Comparisons were made with a standard post-planting 'spot' treatment using $\frac{1}{2}$-pint per plant of an 0.04 per cent aldrin emulsion (2, 3) and with a combined calomel (10 per cent)—aldrin (0.19 per cent) dip used by Wiggell (private communication).

Reductions in clubroot were recorded seven weeks after planting with all the dip treatments, these being greatest with the calomel-aldrin dip and with the dips in which the sticker was incorporated. In contrast to previous results the spot treatment produced only a slight reduction in disease. At the final harvest, 9-10$\frac{1}{2}$ weeks after planting, the clubroot on all the treatments was found to have increased considerably. The greatest reduction was obtained with the calomel-aldrin dip. Less marked effects were observed with the aldrin treatments. Increases in weight of the tops of more than 65 per cent over the untreated controls, were obtained with some of the aldrin plus sticker dips. Despite the marked effect on clubroot, the calomel-aldrin treatment produced only a 38.5 per cent increase in yield. This was probably due to an initial check to growth caused by the treatment.

Field trials of cabbage selections bred for resistance to clubroot by Dr. J. C. Walker, of Wisconsin University, were laid down at the Luddington E.H.S. and at a farm in Hampshire. Considerable clubroot was observed on low resistance British and American control plants, while varying degrees of resistance (some extremely high) were recorded on the test selections. Although requiring a longer period for maturation, some of the resistant types compared favourably with current summer cabbage

varieties. Selections have been made from the trials for further development, in collaboration with the Plant Breeding Section.

LEAF AND POD SPOT OF PEAS (R. B. Maude)

Tests of seed treatments to reduce or eliminate seed-borne infection have been continued, using seed of the variety Kelvedon Wonder which was infected with *Mycosphaerella pinodes*.

Heating seeds in carbon tetrachloride to a temperature of 70°C. for three hours caused no loss in germination and reduced the proportions of infected seed from 90 to 22 per cent. Soaking seeds in 1 per cent (active) captan-water suspension for 24 hours gave an average disease reduction from 85 to 5 per cent. Studies on the mechanism of this effect showed that a fungicidal material from the suspension penetrated deeply into the seeds when these were fully imbibed. Seeds treated in this and other liquid steeps could be redried by placing them in an air stream at a temperature of 21°C. and they retained their viability. In other tests it was found that seed treatment with a 50 per cent thiram dust, using a sticker, also reduced the percentage of infected seeds.

None of the treatments tested so far has completely eliminated seed-borne infection but it should be noted that all the experiments have been made with very heavily diseased samples. The effects of the treatments on commercial samples containing smaller percentages of infected seed will be tested in future experiments.

BIG VEIN DISEASE OF LETTUCE (J. A. Tomlinson and Bridget R. Smith)

A study was made of the *Olpidium* fungus found to be present in the roots of lettuce plants showing big vein (8). The morphology of the lettuce fungus very closely resembled that of *O. brassicae* (Wor.) Dang., but in pathogenicity the two fungi appeared distinct. Thus, whereas the roots of cabbage plants became heavily infected with *Olpidium* when grown in soil known to be heavily contaminated with *O. brassicae*, those of lettuce plants grown in the same soil did not. Conversely, the roots of lettuce plants became infected with *Olpidium* in soil contaminated with big vein but the roots of cabbage plants were uninfected.

When the roots of lettuce plants showing big vein symptoms were suspended for 5-10 minutes in river or tap water, large numbers of *Olpidium* zoospores were released from zoosporangia into the water. If a suspension of such zoospores was watered on to the soil in which lettuces were growing the plants developed big vein symptoms after 3-4 weeks. Infection thus occurred more quickly than by the methods previously used (9) and the technique is of considerable value in experimental work on the disease.

It was found that zoospores were not released in distilled water at *p*H 5.2 or in river water adjusted to *p*H 5.2 using CO_2 gas, although they were readily released in untreated river water at *p*H 7.9. Adjustment of the *p*H value of soil to various values from 4.9-8.0, however, had no effect on the development of the disease following soil inoculation.

LETTUCE MOSAIC DISEASE (J. A. Tomlinson and Bridget R. Smith)

This disease was widespread on commercial holdings in 1959, presumably because the hot, dry summer favoured the spread of the virus by aphids.

A preliminary study was made of the possibility of controlling the disease by the use of 'mosaic tested' seed stated by the supplier to contain less than 0.1 per cent infection. Control of mosaic in Britain by sowing seed with minimal mosaic infection was suggested by Broadbent (1) and this method has been used successfully in the U.S.A. by Grogan (5). The results of the present trials were variable but it was clear that if such seed was sown away from infected lettuce the crop remained substantially free from the disease. The disease rapidly entered the crop, however, from other trials

in which infected plants were growing about 200 yards away. The trials have emphasised the importance of ensuring adequate isolation for successional crops of lettuce.

POWDERY MILDEW DISEASES (J. A. Tomlinson and M. J. W. Webb)

Investigations were continued on the development of turnip mildew (*Erysiphe polygoni*) following treatment of the plants with zinc compounds. The growth of the fungus on the leaf surface was studied after dusting spores on to turnip leaf disks, 1 cm. diameter, placed on damp filter paper in petri dishes incubated at 21°C. for 48 hours. When placed on disks cut from the leaves of plants grown in soil watered with zinc sulphate the spores germinated but failed to develop beyond the appressorial stage. The same result was obtained if leaf disks from untreated plants were first soaked in zinc sulphate solutions. Such resistance to infection was removed if, following this treatment, the disks were immersed in a solution containing the sodium salt of ethylene diamine tetra acetic acid. Further studies are being made on the development of mildew resistance in leaves by treatment with metals, and on the effects of chelating agents on this resistance.

The effect of zinc on the reaction of other plants to mildew infection was studied by watering the soil in which they were grown with solutions of zinc sulphate (500 p.p.m.). It was found that whereas swede plants became resistant to *E. polygoni*, chrysanthemum and gooseberry plants remained respectively as susceptible to *Oidium chrysanthemi* and *Sphaerotheca mors-uvae* as the untreated controls, despite the accumulation of zinc in their leaves.

Other metals found to confer resistance to mildew infection on turnip plants were nickel and cadmium.

Acknowledgments

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WEED INVESTIGATIONS

By H. A. ROBERTS

ECOLOGY (Sheelagh M. S. Hird and H. A. Roberts)

Studies of the changes in the numbers of viable weed seeds in the soil on plots of the cultivation experiment (2) have been continued. During the fourth year of cropping, there was a further fall in the average weed seed population to only 8 per cent of that originally present in 1953. It was again found that there were greater numbers of seeds of annual meadow grass (*Poa annua*) on plots which had received rotary cultivation than on those that had been ploughed, although this difference was less marked than in previous years.

Tests with several annual weed species were carried out to determine the minimum period after flowering necessary for the production of viable seed. With groundsel (*Senecio vulgaris*) in August, it was found that achenes capable of germination were present in the capitula five days after anthesis, whilst ripe seed was formed 11 days after anthesis. These intervals became longer later in the season and by November had extended to 20 and 25 days.

A study has been started of some aspects of the biology of three species of mayweed (*Matricaria chamomilla*, *M. matricarioides* and *M. maritima* ssp. *inodora*). All three species can occur as weeds of vegetable crops and may assume importance because of their relative tolerance to certain herbicides.

CHEMICAL CONTROL (H. A. Roberts and B. J. Wilson)

Experiments on the use of dinoseb (amine) as a residual pre-emergence herbicide in runner and French beans were continued. In field trials with runner beans, dwarf French and climbing French beans, good weed control was obtained without crop damage. Trials of this method of weed control were carried out in 1959 by the N.A.A.S. and, following publication of an article in the spring of 1959 (3), also by growers. The reports which have been received indicate that the method is proving successful.

Simazine was again used as a residual pre-emergence treatment in spring-sown field beans and in broad beans, and the results were similar to those obtained in 1958 (4). At $\frac{3}{4}$ lb. per acre, simazine gave excellent control of weeds without adverse effect on yield, but higher rates caused crop damage. A mixture of chlorpropham (CIPC) 1 lb. plus fenuron $\frac{1}{4}$ lb. per acre also gave good weed control and did not affect the yield of either crop. This chlorpropham/fenuron mixture also gave good results in peas.

A further experiment with residual pre-emergence sprays of simazine on sweet corn confirmed previous results. Almost complete weed control throughout the life of the crop was achieved and there was no adverse effect on crop yield or maturity. Work with simazine as an alternative to monuron for annual weed control in asparagus was continued.

Exploratory tests were carried out to determine the potentialities for residual pre-emergence use in vegetable crops of three substituted triazines related to simazine. Their effects on weeds and on a range of vegetable crops were compared with those of simazine in three experiments, and individual compounds were included in yield trials with various crops. Atrazine appeared to be the most phytotoxic of the chemicals and did not exhibit adequate selectivity in any of the 12 vegetable crops present in the tests. Propazine killed weeds to approximately the same extent as did simazine and showed greater selectivity in carrots, parsnips and parsley. Trietazine appeared to be

the least phytotoxic of the four, and somewhat higher rates were required in order to secure weed control. Such rates, however, had little effect on broad beans, dwarf French beans, field beans and peas. Propazine and trietazine appear promising as potential pre-emergence treatments in the crops mentioned, and work with them will be continued.

Exploratory tests were also begun with amoben (3-amino-2, 5-dichlorobenzoic acid) as a residual pre-emergence herbicide. Crops in which good results were obtained included carrots, parsnips and parsley, whilst the large-seeded legumes also appeared to show some tolerance towards this chemical. The prolonged dry weather during the summer prevented these initial results from being followed up, but further trials with amoben are planned for 1960.

Other work included tests with propham and chlorpropham on drilled and transplanted lettuce, and comparisons of chlorpropham with and without admixture of fenuron on autumn and spring-sown onions. On the light soil of Wellesbourne, almost complete control of chickweed (*Stellaria media*) and annual meadow grass was obtained throughout the winter with a pre-emergence application of $\frac{3}{4}$ lb. chlorpropham per acre to autumn-drilled White Lisbon onions. Addition of fenuron always caused greater crop damage than that resulting from chlorpropham alone.

In collaboration with Dr. K. Holly of the A.R.C. Unit of Experimental Agronomy, a bioassay method has been developed for the estimation of residues of substituted urea and triazine herbicides in the soil. The method will detect quantities equivalent to 0.08 lb. per acre mixed with two inches of soil and has been used to follow the course of disappearance of these herbicides from treated field plots.

SPRAY DRIFT (J. M. Way)

The main purpose of the work in 1959 was the determination of the type and severity of injury symptoms induced by MCPA in vegetable crops growing under field conditions. Replicated field experiments were carried out in which crops were treated with sub-lethal dose rates of MCPA (sodium). The treatments were applied by means of an Oxford Precision Sprayer (1) mounted on a trolley and delivering a volume rate of 10 gallons per acre at 30 p.s.i. The dose rates employed were in the range of from 0.10 lb. down to 0.005 lb. acid-equivalent per acre.

Greatest attention was devoted to lettuce and carrot, but experiments were also carried out with parsnip, onion, dwarf French bean, red beet, cauliflower and Brussels sprouts. Detailed observations and photographic records were made of the epinastic and formative effects appearing in these crops following treatment. Growth of the crops was studied by sampling at intervals after treatment and effects on final yield and marketability were measured. The effect of treatment at different stages of growth was studied in lettuce, carrot and dwarf French bean and the responses to 2,4-D and MCPA compared in lettuce, carrot and red beet.

Visits were made to inspect instances of spray drift damage to vegetable crops of which notification was received through the courtesy of the N.F.U. and the N.A.A.S.

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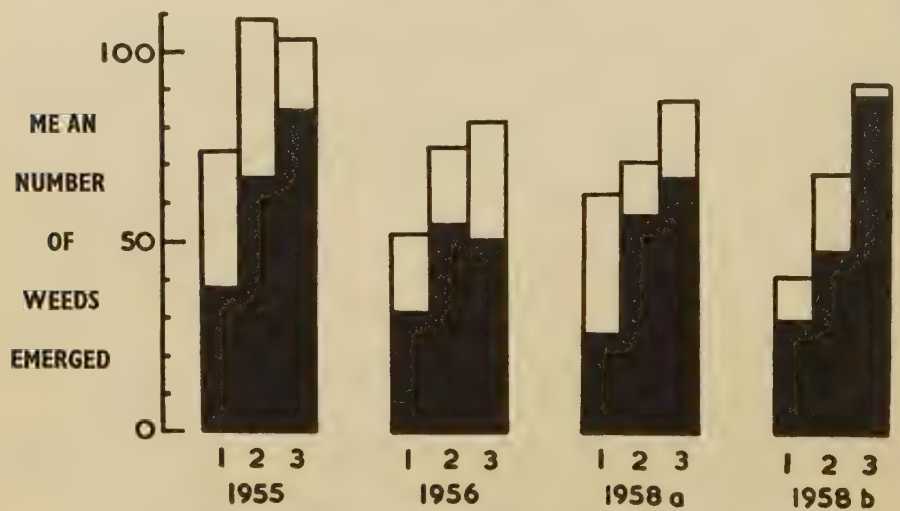
THE EFFECTS OF DIFFERENT METHODS OF SEED-BED PREPARATION ON WEED EMERGENCE

By J. K. A. BLEASDALE and H. A. ROBERTS

The advent of pre-emergence herbicides, both contact and residual, has emphasised the need for knowledge of the conditions affecting the emergence of weed seedlings. It is generally believed that the operations involved in producing a seed-bed can affect the number of weed seedlings that subsequently appear, but a search of the literature revealed little quantitative information regarding the effects of surface soil conditions on weed emergence. A series of field experiments was accordingly carried out to determine the effect of fineness of tilth and of rolling on the emergence of weed seedlings.

Experimental

Four experiments were carried out, one each in 1955 and 1956 and two in 1958. A plaid design was used in which there were three different surface cultivation treatments, with and without rolling. The plot size was 6 ft. × 6 ft., of which the centre strip of 6 ft. × 3 ft. was recorded, and in each experiment there were six replications. The soil was a sandy loam which was ploughed during autumn or winter and allowed to weather on the furrow. In March (April for the second 1958 experiment) the whole area received the first cultivation and the plots were marked out immediately afterwards. In 1955 and 1956, this first cultivation was done with disc harrows, while in 1958 pitch-pole harrows were used. One series of plots was left in this comparatively rough condition, a second series was raked by hand to simulate drag harrowing, and the third series received rotary cultivation with a two-wheeled machine working to a depth of 4-5 inches, followed by levelling with a rake. These operations produced three degrees of fineness of tilth, that resulting from rotary cultivation being the finest, and also tending to be fluffy. The rolled plots received two passes at 1-2 m.p.h. of a 2¼ cwt. flat iron roll immediately after the tilth had been prepared.



Effect of different surface cultivations and rolling on the subsequent emergence of weed seedlings.
1 = 'disced', 2 = 'harrowed', 3 = rotary cultivated.
Open areas represent increases in number due to rolling.

After an interval of from 35 to 60 days, when the initial flush of weed germination was complete, random quadrat counts were made individually for the main weed species and for total species. In 1956 several successive counts were made in order to determine the rate of weed emergence, while in 1958 counts were made twice weekly of the weeds present in permanent quadrats.

Results

The effects of the treatments on the final number of emerged weeds are illustrated in the above figure. In each of the four experiments there was a tendency for greater numbers of weeds to appear with increasing fineness of surface tilth. The average increases in number, relative to that on the 'disced' plots, were 54 per cent and 83 per cent respectively for the 'harrowed' and rotary cultivated plots. There was also a consistent effect of rolling; an average of 42 per cent more weeds appeared on the rolled plots than on the plots which had not been rolled. In three out of the four experiments, the proportionate increase due to rolling was greatest with the roughest seed-bed. After transformation to logarithms, analysis of variance was carried out on the data and the means and standard errors of differences are shown in Tables I and II. In each experiment, the components for 'cultivations' and 'rolling' were statistically significant at $P=0.05$ or less. No consistent differences were found in the response of individual weed species to the treatments.

TABLE I

Effect of surface cultivation on the total weed emergence

Cultivation	Log. number of weed seedlings			
	1955	1956	1958a	1958b
1. 'Disc'	1.70	1.56	1.59	1.46
2. 'Harrow'	1.92	1.78	1.78	1.74
3. Rotary	1.96	1.80	1.87	1.90
s.e. of diff. (10 d.f.)	±0.05	±0.07	±0.07	±0.10

TABLE II

Effect of rolling on the total weed emergence

Cultivation	Log. number of weed seedlings			
	1955	1956	1958a	1958b
Rolled	1.96	1.82	1.85	1.76
Not rolled	1.76	1.60	1.65	1.64
s.e. of diff. (5 d.f.)	±0.04	±0.03	±0.04	±0.03

The data obtained from the permanent quadrats showed that at any one time the proportions of the ultimate totals which had emerged were similar for all the treatments, so that the numbers on the plots of the different treatments were in the same relative order throughout the period of recording.

Discussion

These experiments have shown that there was a general tendency for greater numbers of weed seedlings to emerge as the fineness of the tilth was increased. A similar result has been reported by Arai and Chisaka (1959) who found that emergence of *Alopecurus aequalis* on coarsely harrowed soil (clod size 1-5 cm.) was only 60 per cent of that on finely harrowed soil (clod size less than 1 cm.). Russell and Mehta (1938) showed that in their experiments the cultivation treatments had differential effects on the vertical distribution of weed seeds in the soil, and emergence was, therefore, affected. In the present experiments, the depth of working was such that this factor is unlikely to have operated to any great extent. The different tilth conditions could not be reproduced exactly in the different years, however, and this, together with variations in soil moisture and weather, probably accounted for the fact that the relative numbers of weeds appearing on the plots of the three cultivation treatments were not the same in all the experiments.

The effect of surface compaction by rolling was to increase the number of weed seedlings that emerged. It must be stressed that in all the experiments the soil was in a friable condition after winter frosts, and rolling caused some breakdown of clods as well as surface compaction. Larson, Klingman and Fletchall (1958) carried out experiments with a smoothing and rolling device which had a similar effect in removing clods as well as compacting the surface, and this treatment resulted in an average increase of 60 per cent in the number of weeds that emerged compared with that from the normal seed-bed. Rolling would not be expected to result in increased weed emergence if the degree of compaction was too great or if soil conditions were unfavourable. Arai and Chisaka (1959) found that compaction of their soil reduced the emergence of *Alopecurus aequalis*, and they demonstrated a high correlation between the numbers emerged and the porosity of the soil.

When a crop is sown with a drill with a press wheel, the soil behind the wheel is often smoother and more compact than it was before passage of the drill. To determine whether this had any effect on the numbers of weed seedlings that emerged, a series of paired rectangular quadrats was counted, within and adjacent to the track of the drill press wheel. On a medium-fine seed-bed, the number within the row was 12 per cent greater than that outside it, a difference which was statistically significant at $P=0.03$. On a coarser seed-bed, where the last operation had been rolling with a Cambridge roll, the number of seedlings in the row was 36 per cent greater, significant at P=less than 0.05. Further data would be desirable, but these results do suggest that the factor is one which could well be taken into account when assessing the results of experiments with herbicides.

As Larson *et al.* (1958) have remarked, it is often stated that for effective use of a residual pre-emergence herbicide the seed-bed should be smooth, although they also cited work which showed no advantage in this. Their own experiments indicated that because of greater weed emergence on plots which had been smoothed and compacted, the final effect of such herbicides was actually poorer than that obtained on the normal seed-bed. Presumably much depends on the efficiency of the herbicide employed and the length of time for which toxic concentrations persist in the soil. If the herbicide is expected to give almost complete control for a considerable period, there would seem to be an advantage in having a fine seed-bed, as this would lead to the greatest depletion of the weed seed reserves in the soil. On the other hand, if cultural methods or contact pre-emergence sprays are to be relied on for weed control, the results of the experiments suggest that it would be desirable to use the roughest seed-bed compatible with securing good crop establishment, as this would be likely to result in survival of the fewest weeds.

SUMMARY

Four field experiments were carried out to determine the effects on weed emergence of three degrees of fineness of tilth, with and without rolling. These showed that weed numbers increased with increasing fineness of tilth and that there were greater numbers on the plots that had been rolled. Some implications of these results are discussed.

Acknowledgment

The assistance in the field of Mrs. A. H. T. George, Miss M. E. Smart and Miss U. W. Laurence is gratefully acknowledged.

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STATISTICS REPORT

By J. A. NELDER

The Section's work has continued to be restricted because a vacant post remained unfilled until the last month of the year. A considerable amount of time was spent as usual dealing with statistical problems arising during the work of other sections on the Station; the problems covered a wide range of topics from statistical genetics and particular solutions of the diffusion equation to models for insect ecology and herbicide assays.

Experimental technique

A further experiment was carried out with red beet to test the effect of weeding time on experimental error, and incorporated also were treatments involving methods of sowing and establishment. The evenness of stand obtained with a precision drill was compared with that from a normal drill at the same seed rate and also with that from a normal drill at a higher seed rate with subsequent hand-thinning. The experiment was in randomised blocks with two plots of each treatment in each block to enable individual treatment errors to be estimated, and each plot consisted of two rows, 15 feet in length, which were recorded separately. The results of the experiment showed the complexity of the factors which can affect error in the field. Thus within a plot the precision seeder gave a marked improvement over the normal drill in evenness of stand as measured by the percentage standard error of the distribution of distances between adjacent plants; but between plots no such improvement was noted, probably owing to a trend in stand across the blocks. The relative variance of the mean diameter of the plants at harvest, however, was halved by the use of the precision seeder, and the same effect was produced on marketable weight. Again differences between blocks were not reduced by use of the precision seeder, showing that its value may be chiefly in small-plot experiments.

The effect of early weeding on the variability of marketable yield also varied according to the area considered. There was no significant reduction in variability due to early weeding either between blocks or between rows within plots, but between plots within blocks (i.e., where experimental error would actually be measured), there was a marked effect, early weeding reducing the relative variance to 35 per cent of the value for later weeding. The joint effect of even sowing and early weeding for plots of two rows each of 15 feet was such that one replicate using the precision drill and early weeding was as accurate as four replicates using the normal drill and delaying weeding; however, this result could not be extrapolated to other plots and blocks of markedly different size.

Growth analysis

The possible use of time-scales based on meteorological data for the interpretation of plant growth data derived from long-term experiments has been written up in a joint paper (2). In addition, an efficient method of fitting to plant growth data a family of curves described by Richards (3) has been worked out and a paper prepared for publication.

Two field experiments with carrots have been carried out in co-operation with Dr. Salter. These were designed to discover whether super-normal growth can occur when a period of good conditions follows a period of poor conditions. Such spurts of growth, if they occur, would lead to non-additive effects in a changing environment, and these effects might be of considerable importance in the interpretation of growth data from field experiments. In the first experiment, a check was given to growth by withholding water. For one treatment the drought check occurred in the two weeks

immediately after emergence of the seedlings (4th-18th June); while in another it occurred in the mid-period of growth (16th August-16th September). Control plots were brought to field capacity twice per week throughout the growing season. For neither treatment was there clear evidence of any spurt of growth in the period immediately following the drought check. Rather surprisingly the peak dry weight of tops was increased following the drought check at the cotyledon stage, but there was no corresponding increase in root dry weight. The drought period in August-September, though considerably reducing the increase of fresh weight of both roots and tops, had no discernable effect on the dry weight increase of the roots, though the dry weight increase of tops was reduced, but non-significantly so. The final weight of roots at the beginning of November was not significantly different for the three treatments, but this is not necessarily evidence of recovery from checks, since the shape of the root growth curve implies that differences between treatments will decline as time goes on even when the growth rates for a given size of root are the same.

In the second experiment, somewhat artificial checks were given (i) by cutting off half the cotyledon area six days after emergence and (ii) by removing half the leaf area 30 days later when four true leaves were visible. A control was left untouched and all plots were restored to field capacity twice weekly throughout the growing season. The result of (i) was to delay growth by about three days, and there was no sign of overtaking of the control by this treatment. From the time of expansion of the tap root onwards, top/root ratios were unaffected by the treatment. As a result of treatment (ii) the relative growth of top and root was changed in a way which tended to restore their ratio to that of the control plants. The growth rate of the whole plant per unit weight of tops was not changed in the four weeks after defoliation so that no measurable recovery from this kind of check occurred. However, because of the rapid decline in the top growth, differences in weight of tops due to defoliation fell steadily and were small eight weeks after defoliation. The root weight of defoliated plants had reached 93 per cent of, and was not significantly different from, the controls by the final harvest on 1st November. Again this apparent recovery is merely the result of the normal shape of the growth curves and cannot be regarded as a true recovery from a check.

Thus neither experiment gave any clear indication of recovery from checks to growth similar to those reported from animal growth studies (see e.g. (1)). An interesting by-product of the experiment was the marketable yield obtained in early November following irrigation through an outstandingly fine summer. This averaged 43.5 tons per acre from a crop grown in 10-inch rows with an average of 14 plants per foot of row.

Work for other bodies

The volume of analyses done for the N.A.A.S. increased considerably again. In all, the results from 127 experiments involving 6,813 plots were analysed, each experiment involving an average of three variates. Most of the data came from the N.A.A.S. Experimental Horticulture Stations, and the remainder from other N.A.A.S. sources. J. A. Nelder continued to serve on the Protected Cropping Working Party of the A.I.C.'s Experimental Horticulture Committee and on the N.A.A.S. Vining Pea Group.

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THE WEATHER DURING 1959

RECORDS OF THE N.V.R.S. AGRO-MET. STATION

By CHRISTINE DOWN, E. J. WINTER and R. B. AUSTIN

In contrast to the previous three years, the spring of 1959 was comparatively wet, and was followed by a dry summer. Total rainfall for 1959 was 19.62 inches — about 4.5 inches less than the long-term average. Ample rainfall up to the end of April helped in the satisfactory establishment of most crops, but growth during the dry summer months was generally retarded where irrigation could not be practised.

The weather records for 1959 and the winter of 1958-59 are summarised in the tables and graph.

In the graph the solid line shows the theoretical accumulated loss of water from a green crop fully covering the ground and adequately supplied with water (modified Penman's E_t). In 1959 the soil moisture status was so low by the end of May that water-loss from crops was considerably reduced. The dotted line on the graph shows the measured water loss from weighable monolith lysimeters each two feet in depth, and covered with a grass sward. These lysimeters received only rainfall throughout the summer, and it may be assumed that the soil moisture status within them represented approximately that of the surrounding crop-covered soil. The moisture status of such soil approached wilting point in August 1959.

Estimates based on meteorological data, confirmed by soil observations, showed that by the end of December 1959 the soil at Wellesbourne had not been restored by rainfall to field capacity beyond a depth of about one foot.

A Dynes recording raingauge was installed in November 1958 which records the rate of fall of rain and the time of precipitation. The Irrigation Section is interested in the comparison of the effects of different speeds of natural precipitation on soil tilth with the effects of irrigating at different speeds and droplet sizes. Records from this gauge are being used in conjunction with those from the recording anemometer to determine the direction and speed of the wind during the period of precipitation. This information is being used in a comparative investigation of the performance of different types of raingauge (2).

Beginning on 4th March 1959 continuous records were made of solar radiation intensity using a Kipp solarimeter, D.C. magnetic amplifier and recording milli-ammeter, and of air temperature at four feet above ground level using a mercury-in-steel recorder. Hourly mean values of air temperature and solar radiation intensity constituted the basic data for computing the 'time scales' used in work on crop growth analysis (1). A programme has been prepared in collaboration with our colleague, Mr. J. A. Nelder, and the Statistics Department of Rothamsted Experimental Station, by means of which an electronic computer may be used to carry out various calculations on the data as needed.

A Gunn-Bellani distillometer was installed and operated from 8th April to 28th October 1959. The instrument was mounted so that the receiving surface was at ground level. Under these conditions the daily total distillation was linearly related to total incoming radiation but was also significantly affected by ambient air temperature.

In furtherance of the work of the Irrigation Section on factors affecting loss of water from field soils (3), Garnier transpirometers and British-type evaporation tanks similar to those at Wellesbourne have been installed at Stockbridge House, Efford and Rosewarne E.H.S's. At these Stations, water loss is already being regularly estimated from meteorological data in connection with irrigation experiments, and the new instruments will enable measured values to be compared with estimated values at these widely different sites.

In collaboration with the Meteorological Office, an American Class A evaporation pan was set up near the British standard evaporation tank at Wellesbourne. The daily loss from the American pan during the summer of 1959 was up to 30 per cent more than daily estimates based on the Penman method. On the other hand, as in previous years, the daily loss from the British tank agreed with the estimated loss.

TABLE I

Summary of various weather features during 1959

			*9-year average
Sunshine:	sunniest month	July (daily average 7.15 hours)	5.8 hours.
	dullest month	December (daily average 1.31 hours)	1.4 hours.
	most in a day	14.6 hours on 4th July (88% of possible).	
Rainfall:	wettest month	January (3.57 inches)	2.07 inches.
	driest month	September (0.08 inches)	1.94 inches.
	most in a day	1.11 inches on 6th January	
	total during 1959	19.62 inches	24.11 inches.
Wind:	windiest month	December (daily average run—194 miles)	141 miles.
	calmest month	September (daily average run—85 miles)	111 miles.
	windiest day	7th December (day's run—363 miles)	
	calmest day	6th November (day's run—10 miles)	
	daily average run of wind during 1959—120 miles.		
Air temperature:			
	warmest month	63°F. mean temperature in August	61°F. (8-year average)
	coldest month	35°F. mean temperature in December	37°F. (8-year average)
	highest maximum ...	86°F. on 4th and 5th July.	
During winter 1958-59:			
	lowest minimum	17°F. on 17th January 1959, i.e., 15° of frost.	
	first air frost	31°F. on 1st November 1958.	
	last air frost	30°F. on 7th May 1959.	
	number of nights with air frost—57		70
	number of nights with ground frost—109		103

*The averages refer to the corresponding month or period during the previous nine years. Thus, in the first entry in the table, the average daily number of hours of sunshine for July during the past nine years was 5.8, but July was not necessarily the sunniest month in every year.

(Table II and graph overleaf)

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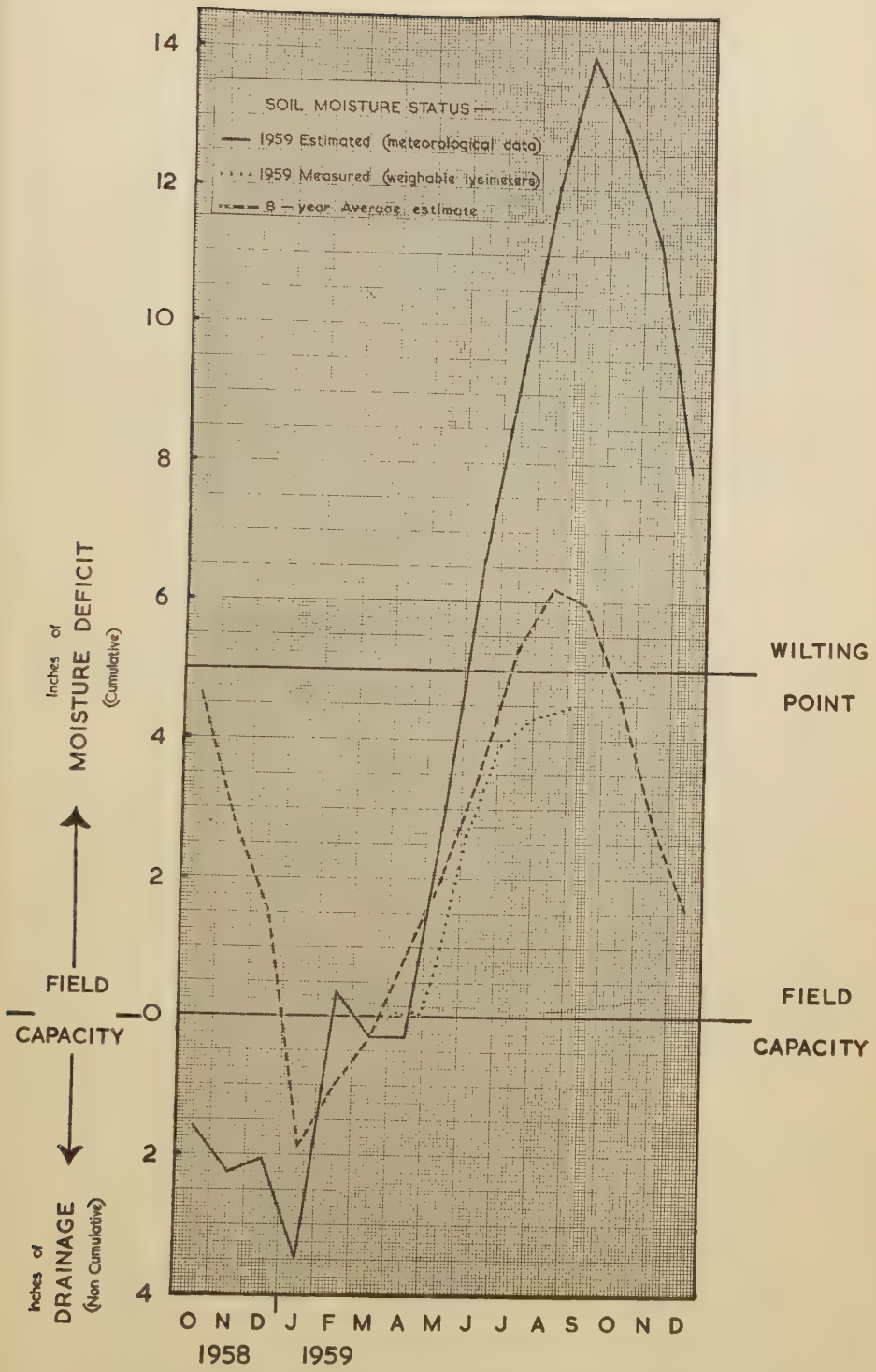
TABLE II

Observations made at N.V.R.S. Agro-Met. Station during 1959

Month	Air temperature °F.		Number of frosts		Mean soil temperature °F. at 0900 hr. G.M.T.			Rainfall		Total sun hours	Total solar radiation. gm. calories	Mean daily run of wind. Miles	Evaporation from water surface. Total inches	Evapo-transpiration from grass surface. Total inches
	Mean Max.	Mean Min.	Air	Ground	4″	12″	48″	Total inches	Number of days with rain					
January ...	40	29	22	23	33.5	36.7	41.5	3.57	17	62.2	1410	113	0.27	0.47
February ...	44	34	14	18	36.7	37.8	39.9	0.10	3	48.8	—	99	0.15	0.22
March ...	52	38	4	11	42.5	44.0	43.9	1.96	15	91.5	4730	147	0.89	1.45
April ...	57	41	0	11	48.7	49.0	47.5	2.60	16	141.9	8699	134	1.96	1.81
May... ...	65	43	3	10	57.2	54.6	52.0	0.48	7	208.7	12013	106	3.24	3.23
June... ...	69	49	0	0	64.5	61.4	57.3	0.48	12	218.0	12622	107	4.43	4.39
July... ...	72	53	0	0	68.1	65.9	62.0	1.68	8	221.8	12231	109	4.94	5.23
August ...	74	53	0	1	65.9	65.3	62.9	0.73	6	207.8	9830	96	3.63	4.45
September ...	71	46	2	3	59.4	61.4	61.8	0.08	2	181.1	8002	85	2.87	3.71
October ...	63	45	0	2	51.2	54.6	57.4	2.33	13	140.9	4747	126	1.58	1.47
November ...	50	37	13	13	42.1	45.1	49.8	2.06	16	58.9	2023	122	0.16	—0.05
December ...	47	37	3	13	39.8	42.2	44.7	3.55	23	40.5	1192	194	0.02	0.69
Total 1959 ...	—	—	61	105	—	—	—	19.62	138	1622.1	—	—	24.14	27.17
9-year average ...	—	—	—	—	—	—	—	24.11	169	1402.4	—	—	—	—



The loss of water by drainage and by evapo-transpiration from a soil fully covered by a green crop.

LIBRARY REPORT

By BARBARA M. MOORE and H. A. ROBERTS

Since July 1954, the library has been housed in a room in the temporary laboratory building. Although at first this accommodation proved adequate, latterly the congestion became acute as both stock and usage increased. It was with great relief, therefore, that the stock was transferred into its permanent home in the new building during the summer of 1959. The new library is a pleasant, airy room providing seven reading bays with space for 25 readers. The stacks, current periodicals rack and librarian's counter were all specially designed and made in Japanese oak. There is a total of approximately 880 feet of shelving, and sufficient space for the introduction of further shelving when this ultimately becomes necessary. A small ancillary room provides work space for the librarian and stack room for infrequently consulted items.

The library has been without a full-time librarian since the end of May 1959, and inevitably there has been some accumulation of separates, for which no current total can be given. Other holdings at 30th September 1959 were as follows:—

Current periodicals	164
Bound periodical volumes	820
Books	490

100 annual reports were received from other organisations in exchange for the N.V.R.S. Annual Report, and in addition various reprint and bulletin series were also obtained by exchange. In April 1959, a mimeographed list of periodical holdings was prepared and distributed to other libraries, and it is hoped to make the issue of such a list an annual event. During the period October-May 163 items were obtained on loan from other libraries. Only 12 items were lent to other libraries but it is expected that, following the issue of the holdings list, lending activities will show an increase.

During the year the library has been the recipient of a number of valuable gifts. A run of 32 volumes of 'Scientific Agriculture' was received from the Reference Library, Canada Department of Agriculture, Summerland, B.C. Dr. Alexander Nelson presented the library with long runs of 'Proceedings of the Royal Society of Edinburgh series B', 'Transactions and Proceedings of the Botanical Society of Edinburgh' and 'Notes from the Royal Botanic Garden, Edinburgh', together with a collection of some 2,500 reprints and pamphlets formed over a period of 30 years. This collection includes reprints of many classical papers in plant physiology and plant genetics, and will be of very great value to the Station. Other gifts of books and reports were received from Miss M. E. Smart, Mr. T. J. Norwood and Dr. J. Philp. All these items are very welcome, and sincere thanks are expressed to the donors.

PUBLICATION RECORD

BLEASDALE, J. K. A. (1959). The yield of onions and red beet as affected by weeds. *J. hort. Sci.*, **34**, 7-13.

(The results are presented of three factorial experiments which measured the effects of two weed densities and of three dates of weeding on crops of onions and red beet. Reducing the weed density by pre-emergence herbicide treatment increased the crop yields and reduced the amount of labour needed to hand-weed the rows. Very early weeding produced the highest yields; the longer it was delayed, the smaller was the marketable yield.

It is concluded that pre-emergence weed control sprays could be profitably used on crops that are to be hand-weeded later or on crops where post-emergence herbicides can be applied only at a fairly late stage of growth).

DUNN, J. A. (1959). The biology of lettuce root aphid. *Ann. appl. Biol.*, **47**, 475-91

(The biology of this important pest of summer lettuce is described in detail, special attention being given to the subject of alternative primary and secondary hosts).

DUNN, J. A. (1959). The survival in soil of apterae of the lettuce root aphid, *Pemphigus bursarius* L. *Ann. appl. Biol.*, **47**, 766-71.

(Experiments showed that wingless lettuce root aphids could successfully overwinter in soil even though their original lettuce host plant had died. Having thus overwintered, they were able to colonise the roots of a spring-planted lettuce crop. They survived pre- or post-winter soil cultivation. The influence of temperature on survival is described).

DUNN, J. A. (1959). The effect of temperature on reproduction by the alatae of *Pemphigus bursarius* L. *Ann. appl. Biol.*, **47**, 772-7.

(The reproductive rate of winged lettuce root aphids was studied at temperatures between 38° and 82°F. The spring migrants gave the greatest total reproduction at about 60°F. but the peak reproductive rate was highest at 70-81°F. Corresponding temperatures for the autumn migrants were 55° and 67°F. approximately. The average outdoor air temperatures prevailing at the time when the respective winged forms are most abundant correspond closely to the temperatures required by the alatae for maximum reproduction).

GREENWOOD, D. J. and LEES, H. (1959). An electrolytic rocking percolator. *Plant & Soil*, **11**, 87-92.

(An electrolytic rocking percolator is described which facilitates the study of the decomposition of any organic material in a water-saturated soil whilst maintaining the soil atmosphere at any constant oxygen partial pressure. The apparatus enables the oxygen uptake to be measured continuously and the soil water to be sampled at frequent intervals during an experiment).

HOLLAND, H. (1959). Making use of the odious bluebottle. *Grower*, **51**, 631.

(A description is given of the method used for rearing pollen-uncontaminated blowflies and storing the pupae until the flies emerge. The use of these blowflies in pollinating onions is also described, and the advantages of this method compared with laborious hand-pollination are discussed).

HUGHES, J. C. and SPRAGG, S. P. (1958). The inhibition of mitosis by reaction of maleic hydrazide with sulphydryl groups. *Biochem. J.*, **70**, 205.

(Treatment of germinating pea seeds with maleic hydrazide (MH) stops mitotic division and this is associated with a marked conversion of GSSG to GSH in the plumule and radical. The MH does not affect the ratio GSH/GSSG in the cotyledons. From a comparative study of the effects of MH on the enzymes β-amylase, starch phosphorylase, trypsin and pea aldolase,

it was found that *in vitro* MH inhibits sulphydryl enzymes irreversibly. These results are interpreted as indicating that in mitotic division of plant cells, the reduction of protein disulphide groups by GSH is of prime importance; MH inhibits this reduction).

KEYWORTH, W. G. (1959). A modified La Rue cutter for selecting single spores and hyphal tips. *Trans. Brit. mycol. Soc.*, **42,** 53-4.

NELDER, J. A. (1959). National Vegetable Research Station new laboratory building. *Nature, Lond.*, **184,** 1368-9.

ROBERTS, H. A. (1959). Evaluation of dinoseb for the control of annual weeds in market-garden peas. *Exp. Hort.* **no. 2,** 19-25.
(Results from a series of trials confirmed the greater selectivity of the amine compared with the ammonium salt of dinoseb, and showed that the amine could be safely applied at a very early stage of growth. Experiments on clean crops of 12 varieties of peas grown for picking green revealed varietal differences in susceptibility to the ammonium salt but indicated that all those tested were tolerant to dinoseb (amine) at the recommended rates. It was concluded that dinoseb (amine) is an effective herbicide for the control of a wide range of annual weeds in crops of market-garden peas).

ROBERTS, H. A. (1959). Dinoseb pre-emergence. 3 lb. per acre can keep runner beans clean. *Grower*, **51,** 166-7.
(A preliminary report on experiments in which dinoseb (amine) was used as a residual pre-emergence treatment for weed control in runner beans and dwarf French beans. When applied immediately after sowing at the rate of 3-4 lb. per acre of actual dinoseb, excellent control of annual weeds was obtained with no crop damage).

ROBERTS, H. A. (1959). Chemical weed control in vegetable crops. *World Crops*, **11,** 245-7.

SALTER, P. J. (1959). The effect of different irrigation treatments on the growth and yield of early summer cauliflowers. *J. hort. Sci.*, **34,** 23-31.
(Responses of early summer cauliflower plants to different soil moisture conditions in the field are described . It was found unnecessary to maintain the soil at field capacity in order to obtain maximum yields, because at least 25 per cent of the available moisture could be depleted before irrigation was needed to maintain maximum growth rate).

SALTER, P. J. (1959). Automatic greenhouse watering. *Amat. Gdng.* 30th May 1959, 8.

SPRAGG, S. P. (1959). Chromatography of thiol compounds. *Nature, Lond.*, **182,** 1314.
(The selective detection of organic compounds containing sulphur was made more easy by complexing the compounds with mercury before separation on paper chromatograms. The complexed ion was then detected by spraying with dithizone solution).

TOMLINSON, J. A. (1958). Crook root of watercress. I. Field assessment of the disease and the role of calcium bicarbonate. *Ann. appl. Biol.*, **46,** 593-607.
(The discovery, occurrence and symptoms of the disease are briefly described. Field assessment of infection showed that the disease increased with increasing distance from the water source, was most severe from October to April and affected brown more than green watercress. River water containing a high concentration of calcium bicarbonate inhibited crook root infection. In laboratory tests, increasing concentrations of calcium bicarbonate from 350-

540 p.p.m. gave an increasing degree of disease control. The same effect was also shown in a small field trial but the control method was too costly to be economic).

TOMLINSON, J. A. (1958). Crook root of watercress. II. The control of the disease with zinc-fritted glass and the mechanism of its action. *Ann. appl. Biol.*, **46,** 608-21.

(A zinc concentration of 0.5 p.p.m. in water was found to control the disease. A high degree of control was obtained in field trials when zinc frit (finely powdered glass frit containing zinc oxide) was applied to watercress beds at rates of 1 and ½ lb. per square yard. Though very insoluble in distilled water, zinc frit was more soluble in distilled water containing CO_2 produced by plants. It was shown that the control of the disease by zinc was caused by the killing of the zoospores).

TOMLINSON, J. A. (1958). Crook root of watercress. III. The causal organism *Spongospora subterranea* (Wallr.) Lagerh. f. sp. *nasturtii* f. sp. nov. *Trans. Brit. mycol. Soc.*, **41,** 491-8.

(The morphology of the fungus responsible for the crook root disease of watercress is described. The host-parasite relations of the disease are briefly discussed and cross pathogenicity studies are described. The fungus was identified as a hitherto undescribed *forma specialis* of *Spongospora subterranea* (Wallr.) Lagerh., differing in pathogenicity from the f. sp. causing powdery scab of potato).

TOMLINSON, J. A., SHEPHERD, R. J. and WALKER, J. C. (1958). Purification and serology of cucumber mosaic virus. *Nature, Lond.*, **182,** 1616.

TOMLINSON, J. A., SHEPHERD, R. J. and WALKER, J. C. (1959). Purification, properties and serology of cucumber mosaic virus. *Phytopath.*, **49,** 293-9.

(A method of purifying cucumber mosaic virus (CMV) was found which involves homogenizing infected tissue in strong buffer containing a reducing agent. The filtrate of the homogenate was clarified with n-butanol and the virus was concentrated and partially purified by differential centrifugation. Acid precipitation and further differential centrifugation of the preparation yielded a purified virus solution, which was found to contain a nucleoprotein with a sedimentation constant of 101S. Electron micrographs showed that air-dried purified virus solutions contained spherical particles with a mean diameter of 40 $m\mu$. An antiserum to the virus with a titre of 1/1024 was prepared from partially purified preparations.

This work was done while the senior author was seconded to the Plant Pathology Department, University of Wisconsin).

WINTER, E. J., SALTER, P. J. and STANHILL, G. (1959). Lysimetry at N.V.R.S. *Publ. 49, Ass. int. hydrol. Sci.*, 44-51.

(A description is given of the instruments and methods used at Wellesbourne for measuring and estimating potential and actual evapo-transpiration of water from different crops. It has been shown that amounts of evapo-transpiration could vary between different crops growing under identical weather conditions.

A method is described for modifying the Penman estimate of potential evapo-transpiration to apply to crops not fully covering the soil and crops not fully supplied with water).

WINTER, E. J. (1959). The pros and cons of irrigation. *Agriculture, Lond.*, **65,** 498-503.

WINTER, E. J. (1959). Irrigation in the garden of the future. *Gdnrs' Chron.*, Chelsea Supplement.

WINTER, E. J. (1959). The irrigation indicator. *Fmrs' Wkly*, Irrigation Supplement, May.

WRIGHT, D. W. and HUGHES, R. D. (1959). Controlling cabbage root fly. *New Scient.*, **6**, No. 139, 74-5.

(The life history of the cabbage root fly, a serious pest of brassica crops, is briefly described. The application of insecticides either as seed dressings or to the base of the newly germinated seedlings gives good control of the damaging larvae. Indiscriminate use of these insecticides, when broadcast or mixed into the soil, may kill more of the natural enemies than of the pest itself, resulting in a greater damage to the plants than if no insecticide had been used at all).

THE JOURNAL OF HORTICULTURAL SCIENCE

The Journal of Horticultural Science, which is sponsored by the Long Ashton Research Station and the East Malling Research Station, welcomes contributions on horticultural science from Research Institutes at home and abroad. Papers for publication and all communications should be sent to the Editors at East Malling Research Station, Maidstone, Kent.

Papers already accepted for publication in the current Volume 35 have been received from both the sponsor Stations, from the National Vegetable Research Station, the Glasshouse Crops Research Institute, the Scottish Horticultural Research Institute, Nottingham, Reading and London Universities and the National Agricultural Advisory Service in the United Kingdom, and from Canada, Trinidad, India and Ghana. Many reports deal with various aspects of apple culture, and raspberries, hops, bananas, custard apples, cocoa and tomatoes are other crops grown for their fruit. A study of yearly variation in vegetable crops is described and aspects of summer cauliflower and radish culture are also dealt with. There is a paper on the effects of environment on chrysanthemum. A wide range of subjects includes plant nutrition, growth studies, breeding, planting density, storage, top grafting and disease control.

The Journal is issued in quarterly parts and is published by Messrs. Headley Brothers, 109 Kingsway, London, W.C.2, to whom intending subscribers should apply. The subscription rates for the current volume are 60 shillings per volume (rate for Canada and the U.S.A., $8.50) or 20 shillings for a single number. Back numbers of several volumes are available from the publishers.

NATIONAL VEGETABLE
RESEARCH STATION
WELLESBOURNE
WARWICK
BRADLEY'S
169
16-037
RUSH PITS
170
11-807
HOSPITAL FIELD
134
3-695
TOWNSEND (WEST)
153
18-388
TOWNSEND
153
2-461
GRAVEL PITS
147
13-108
COTTAGE FIELD (WEST)
138
11-377
COTTAGE FIELD
138
3-46
CHARLECOTE
LONG MEADOW (WEST)
127
9-259
BUNGALOW FIELD
133
1-868
LONG MEADOW
127
9-417
MEADOW PLATS
136
6-34
WHARF GROUND
128
18-196
GALLAS LETS
135
7-779
SHELF PEARS
102
34-226
PUMP GROUND (WEST)
87 and 102
21-399
BIG GROUND
102
33-268
PUMP GROUND
87 and 102
18-62
LITTLE CHERRY GROUND
88
11-23
PLUM ORCHARD (WEST)
78
6-429
BIG CHERRY GROUND
88
34-140
WATER MEADOWS (WEST)
75
6-490
PLUM ORCHARD
78
6-71
SOAKWATERS
90
36-444
WELLESBOURNE GRAVEL PITS
75
22-293
RIVER DENE
BOUNDARY
WATER MEADOWS
70 and 75
17-302
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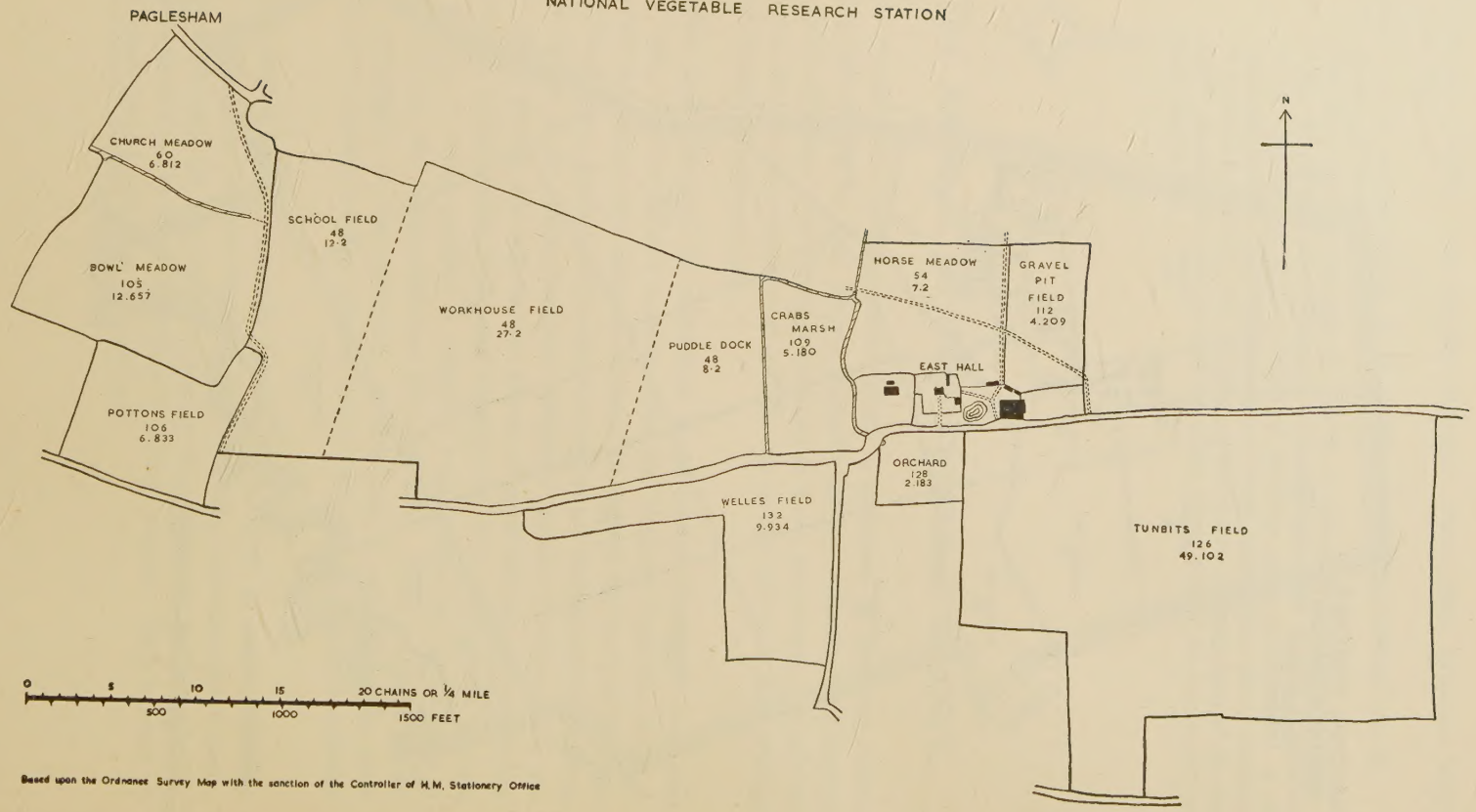

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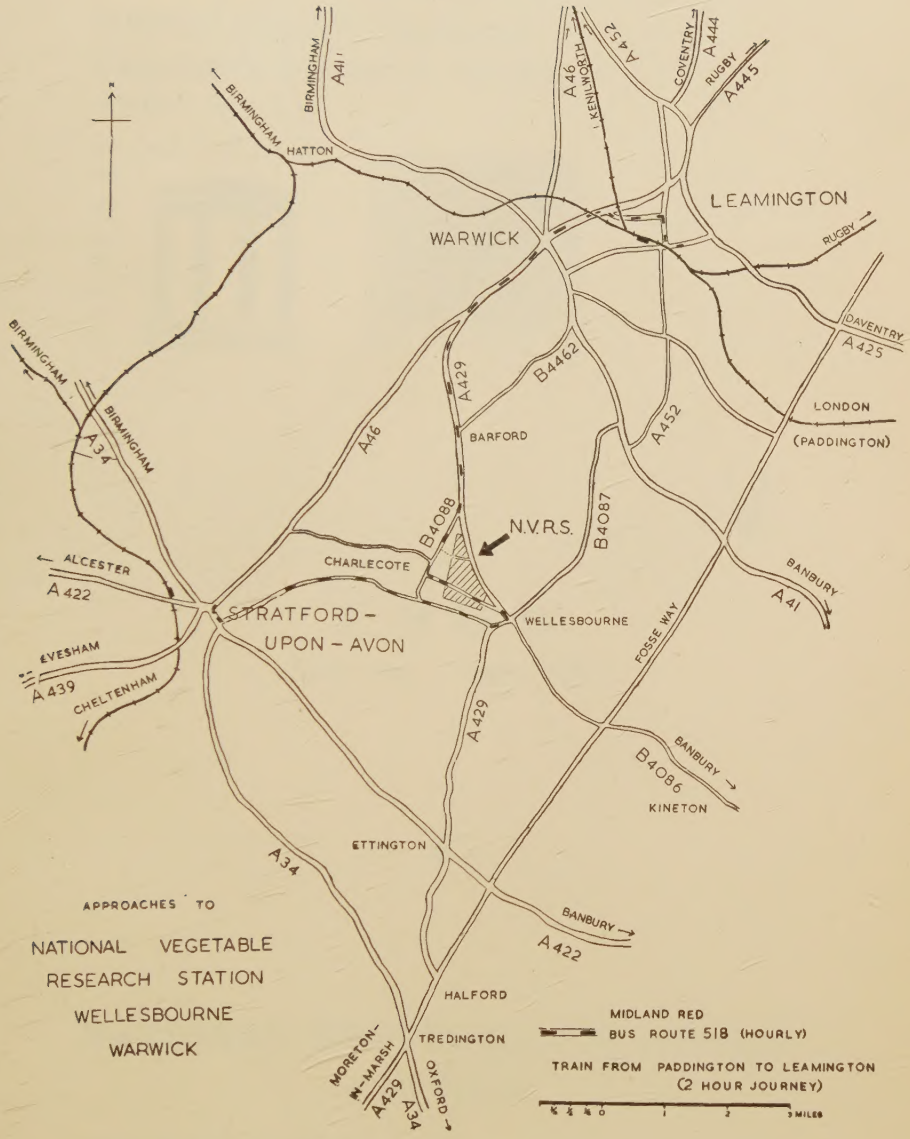
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A425
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A46
A429
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B4088
N.V.R.S.
B4087
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A422
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